IVM - Institute for Environmental Studies

Seeking the sustained operation of rural electrification projects for poverty reduction

A sustainability assessment of the EnDev hydropower initiative in Mozambique

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List of abbreviations

AMES-M	Access to Modern Energy Services - Mozambique
AKSM	*Associacáo Kwaedza Simukai Manica*
DIPREME	*Direção Provincial de Recursos Minerais e Energeticos,* the Provincial Energy Authority in Manica province.
EAO	*Escola de Artes e Oficios*; School of Arts and Crafts
EIA	Environmental Impact Assessment
EnDev	Energising Development
EUR	Euro (average exchange rate of EUR/MZN in July 2011 = 1:42)
FGDs	Focus group discussions
FUNAE	*Fundo Nacional de Energia;* National Fund of Energy
GIZ	*Deutsche Gesellschaft für Internationalle Zusammenarbeit,* former GTZ
HH	Household
ISPM	*Instituto Superior Politecnico de Manica*; High Polytechnic Institute of Manica
kW	Kilo watt
MDGs	Millenium Development Goals
MoE	Ministry of Energy
MZN	Miticais, the currency of Mozambique
RF	Revolving Fund
RETs	Renewable energy technologies
SAF-EnDev	Sustainability Assessment Framework for EnDev project activities
UCM	*Universidad Catolica de Mozambique*; Catholic university of Mozambique
UP	*Universidad Pedagogica Chimoio*; Chimoio Pedagogic University

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Executive summary

It is agreed by the international community that access to energy is a basic requirement for achieving the Millennium Development Goals. Under the idea that access to energy is indispensable for raising the gross national product and fuel the engine that will take the population out of the poverty trap, the Dutch and German governments initiated in 2004 the Energising Development programme (EnDev), which aims to give access to sustainable and affordable energy to 6 million people in the developing world. A first phase, EnDev I, was developed between 2004-2009, and a second phase EnDev II runs in the period 2010-2012. As of February 2011, 24 project activities were implemented in 21 countries by the EnDev initiative, totalling 5.01 million of beneficiaries with access to electricity or improved cooking technologies.

In this context, NL Agency – a unit of the Dutch Ministry of Economic Affairs – responsible for the EnDev implementation from the Dutch side, requested in 2010 the Institute for Environmental Studies (IVM) at VU University Amsterdam to elaborate a methodological framework aiming to assess the sustainability of the projects implemented under the EnDev initiative. Such framework was developed by IVM and a first version was finalized in March 2011: the "Sustainability Assessment Framework for EnDev project activities" (SAF-EnDev). The SAF-EnDev tool was applied on a trial mode during the first half of 2011 in two EnDev intervened countries: Senegal and Mozambique. This research focuses on the sustainability assessment of the EnDev micro and pico hydropower component in Mozambique.

In the field of international cooperation, the concept of sustainability is linked to the idea that development projects are sustainable when they are capable of supplying an appropriate level of benefits during an extensive time period after the withdrawal of all forms of support from the external agencies. In the most basic sense, this idea means that the projects promoted will have a sustained operation if they have the ability to at least cover their operational costs.

The sustainability assessment of the EnDev hydropower initiatives in Mozambique showed that the atmosphere existing in the country for the diffusion of micro/pico hydropower technologies is still poor and needs to be further developed in order to provide a suitable enabling environment for the sustained operation of the EnDev hydroelectric systems. At the same time, meanwhile the consumers/beneficiaries of the EnDev hydropower electrification projects extremely appreciate the access to electricity provided; they have difficulties in complying with the economic commitments that the benefit entails. Hence, the EnDev business model and enterprise design for the hydropower initiatives funded by the programme in Mozambique needs to be further developed and adjusted to the real socio-economic characteristics of the communities targeted for intervention.

Notwithstanding the aforementioned, it is very likely that the hydroelectric systems implemented during the Mozambican EnDev I phase will enjoy a sustained operation given the way how these were funded and the almost non-existent operational costs.

1 Introduction

The UN Millennium Summit in 2000 set the Millennium Development Goals (MDGs) which have set forth steps through which the international community has pledged to reduce extreme poverty by 50% between 2005 and 2015. As part of this pledge, The Netherlands plans to provide access to up-to-date energy services to 10 million people living under the line of poverty in the developing world (GTZ - NL Agency, 2010) under the idea that access to energy is indispensable for raising the gross national product and fuel the engine that will take the population out of the poverty trap (GTZ, 2007). Such access is seen as a crucial step for the development of societies as a whole, as was acknowledged by the international development community at the 2000 World Summit on Sustainable Development in Johannesburg. Modern energy services help drive economic growth by improving productivity and enabling local income generation through improved agricultural development and non-farm employment. When they are available to all income groups, modern energy services are also an invaluable means of improving social equality (Modi, 2006).

1.1 The Energising Development programme

In the context described above the governments of Germany and The Netherlands established jointly in 2004 the Energising Development programme (EnDev) as a joint implementation initiative aiming to give access to sustainable and affordable energy to 6 million people in the developing world. The programme was initiated internationally in 2004 with its first phase, EnDev I, which gave access to energy to an estimated number of 3.2 million people until December 2009. The second phase of the programme, EnDev II, was initiated in 2010 and it aims to supply at least an additional 3 million people with access to modern energy services until 2014 (NL Agency)

The EnDev initiatives are implemented by the German organization *Deutsche Gesellschaft für Internationalle Zusammenarbeit*[1] (GIZ) in co-operation with NL Agency[2], a unit of the Dutch Ministry of Economic Affairs. While NL Agency contributes its expertise in the fields of monitoring and evaluation, GIZ uses its infrastructure in developing countries and its experience in setting up and implementing energy programmes.

The Energising Development programme aims to significantly expand energy access in four areas:

- Energy for cooking. About 2.4 billion people still use firewood for cooking and heating, causing rapid forestry depletion and respiratory disease;
- Energy for lighting and household appliances. The programme aims to establish sustainable electricity access in rural communities through the use of different technologies: micro-hydropower, solar photovoltaic cells, etc;
- Energy for social infrastructure. The programme aims to provide electricity for schools, clinics, and community centres;

[1] http://www.giz.de/

[2] http://www.agentschapnl.nl/en

- Energy for productive use & to generate income. Productive uses of energy alleviate poverty by generating income for families and communities.

In February 2011 the EnDev portfolio consisted of over 24 project activities in 21 countries, all with the same basic goal but slightly different approaches. Technologies and services predominantly promoted in EnDev's country programmes include photovoltaic energy, grid densification, micro/pico-hydropower, energy-efficient cooking stoves and biogas.

The long-term sustainability of the projects – in the sense that the initiatives will remain operational and originating the expected benefits once the European support ends[3] – is a core criterion for the activities to be supported by the EnDev initiative and special attention is given to the developmental effects of the energy activities implemented. This means aiming to establish or enhance self-sustaining markets for affordable energy technologies, fuels and services adapted to the needs, without creating a long-term dependency on external donor funding (NL Agency).

1.2 Focus of this research

With the aim of having an idea of the sustainability of the projects being implemented in the developing world by the EnDev programme, during the last semester of 2010, NL Agency in The Netherlands requested the Institute for Environmental Studies (IVM) at VU University Amsterdam to elaborate a methodological framework aiming to assess the sustainability of the projects implemented under the EnDev interventions. Such methodological framework was developed by a group of researchers[4] at IVM under the IS Academy[5] initiative and a first version of the framework was finalized in March 2011, the "Sustainability Assessment Framework for EnDev project activities" (Barua, R., van der Kroon, B., Tigabu, A., 2011), hereafter SAF-EnDev.

In order to test the SAF-EnDev methodological tool developed by IVM/IS Academy, NL Agency requested to apply the tool in-situ; hence two EnDev intervened countries were selected by NL Agency with the intention of testing the framework. The countries selected were Senegal and Mozambique, where the EnDev programme initiated its intervention in 2004.

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[3] For the purpose of this research, the concept of sustainability entails the idea that the projects will be capable to supply an appropriate level of benefits during an extensive time period after the withdrawal of all forms of external support. This issue is later discussed in Section 2.

[4] Barua, R., van der Kroon, B. and Tigabu, A.

[5] IS Academy is a joint initiative investigating how the Netherlands can promote the use of renewable energy in developing countries with the goal of improving access to affordable energy, support development and reduce poverty and increase energy security at the national level. The project is commissioned by the Department of Research and Communication (DCO), Ministry of Development Cooperation (DGIS) both from the Netherlands. The Dutch project partners are Energy research Centre of the Netherlands (ECN), Unit Policy Studies, Department of Environment and Water, Ministry of Development Cooperation (DGIS) and the IVM.

Thus, this research focuses on the EnDev programme intervention in Mozambique and has two well defined objectives: on the one hand the research aims to test the SAF-EnDev tool developed by IVM/IS Academy and suggests possible improvements to it; and on the other hand the research aims to assess the sustainability of one of the components of the EnDev programme intervention in Mozambique utilising the newly developed SAF-EnDev tool. Hence, the focus of this research could be conceptually summarized as follows:

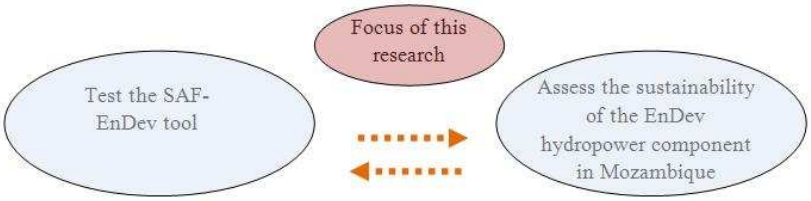


Figure 1: Conceptual image of the focus of this research

For this last purpose the hydro power component of the EnDev programme in Mozambique was selected and entrusted by NL Agency to be assessed[6].

In the context described, the overarching questions of this research are:

- *To what extent are the EnDev hydropower systems implemented in Mozambique sustainable?*
- *How could the "Sustainability Assessment Framework for EnDev project activities" be improved?*
- *Which initiatives could be undertaken in order to improve the sustainability of the micro/pico hydropower systems implemented by the EnDev programme in Mozambique?*

These questions have an exploratory nature and therefore qualitative research tools were utilized to address them. To answer the first question, the SAF-EnDev tool was used. Meanwhile for the second and third questions, findings and insights gathered when applying the SAF-EnDev framework were employed.

The answer to the first question is presented in Section 4 of this report, in the *Results* chapter. The answers to the second and third questions are presented in Sections 5 and 6 respectively: the

[6] A similar work was entrusted by NL Agency for the EnDev solar PV component in Senegal. The result of such research is the report "*Between profitability and poverty eradication: assessing the sustainability of rural electrification initiatives - An evaluation of the solar-powered electrification project ERSEN in Senegal*" developed by Thea Renner as her Research Project for ERM graduation at IVM in the academic year 2010/2011.

Critical perspective of the EnDev Sustainability Assessment Framework; and *Conclusions and Recommendations* chapters.

1.3 Energising Development in Mozambique: Access to Modern Energy Services – Mozambique

The EnDev programme intervention in Mozambique was initiated in 2004 and was designed to comprise the following components:

i. Electricity grid densification;
ii. Micro/Pico hydropower systems[7]; and
iii. Small solar photovoltaic (PV)

The intervention has been led in the country by the German organization Deutsche *Gesellschaft Fur Internationalle Zusammenarbeit* (GIZ, former GTZ) as the EnDev implementing agency and has been developed under the name "Access to Modern Energy Services - Mozambique" (AMES-M).

Mozambique's state of affair and the national energy sector

Mozambique got independence from Portugal only in 1975. After 15 years of civil war (1977-1992), the country enjoys now a peaceful period with a steady economic growth (4.5% in 2009). The current president is Armando Guebuza from the FRELIMO party, as his two predecessors. With a population estimated in 20,266 million in 2009, the country is divided in 10 provinces and Maputo, the capital city with provincial status (Government of Mozambique). The main exports of the country are aluminum (59.2%), electricity (9.4%) and natural gas (5.56%). The country's commercial exchange is mainly with The Netherlands, South Africa, Portugal and Spain (Mozambican Investment Promotion Centre).

The energy sector is marked with a low 14% of electricity access. The power generation sector is dominated by the hydroelectric plant Cahora Bassa, located on the Zambezi River in Western Mozambique. It contributes to 87% of the 2.4 GW installed capacity in the country and exports two-thirds of its output to South Africa. The most relevant institutions in the energy sector are Electricidade de Moçambique (EdM, a governmental owned corporation) which is responsible for the transport, distribution and commercialization of electricity in the country, the Ministry of Energy (MoE) and FUNAE, the National Fund of Energy.

Source: Government of Mozambique and Mozambican Investment Promotion Centre

1.3.1 AMES-M hydropower component

The work of AMES-M on the hydropower component was initiated in 2007 in the Mozambican western province of Manica. The region enjoys sufficient water flows from the mountains

[7] Micro hydropower systems have between 5-100 kW of installed capacity. Pico systems have no more than 5 kW of capacity.

throughout the year mainly in the western part of the province along the range of mountains that stretch from Ruenha River in the north to Save River in the south.

AMES-M has worked its hydropower component in two phases (EnDev I and EnDev II). The first phase – EnDev I – was developed between 2007-2009 and consisted in a pilot project in Manica region that aimed to prove the potential and feasibility of implementing micro and pico hydropower systems in that region of the country.

The pilot project consisted of the rehabilitation of four existing corn mills in the community of Chua, a small village in Manica province, located at 16 kilometres from Manica city. The rehabilitation consisted in the augmentation of capacity of the existing mills in a way that they also allow the generation of electricity. Four hydropower systems were then implemented during this pilot project benefiting 136 households that were directly connected to the electricity. The pilot project also considered the lighting of public areas within the Chua village, totalling a number of 920 people benefiting from the four hydroelectric systems implemented as part of the EnDev I pilot project phase and its hydropower component[8].

The micro hydro power plants currently operating in Chua provide milling services during half the day and electricity services during late afternoon and at night (18:00 to 6:00 the next day). The experiences gained with the pilot project show that individual scheme implementation can be fast and generates direct benefits immediately.

Figure 2: Map of Mozambique enhancing Chua village

Crucial for the implementation of the EnDev I hydro pilot phase was the contact with local partners that had knowledge of the local circumstances and enjoyed good acceptance from the communities to being intervened; and with whom GIZ could be able to partner for the next phases on the EnDev intervention. A local NGO based in Manica city was selected for the work: *Associacáo Kwaedza Simukai Manica*[9] (AKSM), who became the implementing partner of GIZ/AMES-M in Manica province for the EnDev I phase. For more details on the EnDev I hydropower pilot project in Chua please see Annex I.

The implementation of micro and pico hydropower initiatives in Mozambique is still a new development which the country does not have major previous experiences with, and therefore an important objective of the EnDev I pilot hydro phase was to start building capacities on these types of renewable energy initiatives among local stakeholders; with this goal GIZ/AMES-M included in

[8] Figures reported in January 2010 by the EnDev promoters in Mozambique (AKSM, 2010)

[9] Name that in local language means "Wake up Manica, is dawn"

its implementation efforts the linkages with governmental agencies such as the local Ministry of Energy (MoE), the National Fund of Energy (FUNAE[10]) and the provincial representative of the Energy Ministry in Manica province, DIPREME[11].

When finalized – during the second half of 2009 – the EnDev I pilot phase in Chua left important lessons for GIZ/AMES-M on how to approach the implementation of the EnDev hydropower initiatives, and most importantly, the technical feasibility of this type of renewable energy generation system was proved in Manica province, increasing the interest of local government in the potential of micro and pico hydropower off-grid solutions. GIZ/AMES-M designed the second phase, EnDev II, again with the local NGO AKSM as the main partner being responsible for the implementation of the hydroelectric systems. This second phase EnDev II, in progress at the time of this research, started during the first half of 2010 and should be finalized by the end of 2012. The EnDev II phase aims to implement 8 micro and 24 pico hydropower systems jointly with several other public infrastructures achieving at the end of the phase a total number of 16,300 beneficiaries for the EnDev II intervention.

This report is organised as follows: Section 2 provides a literature review on the notion of sustainability and what this concept entails for development projects. The research methods, conceptual framework and design of the fieldwork are described in Section 3. Section 4 presents the results of this study regarding the sustainability of the EnDev hydropower systems operating in Mozambique. Section 5 provides a critical view of the SAF-EnDev tool. Lastly, conclusions and recommendations on how to improve the sustainability of the EnDev hydropower systems in Mozambique are presented in Section 6.

[10] *Fundo Nacional de Energia*, FUNAE

[11] *Direção Provincial de Recursos Minerais e Energeticos*, DIPREME

2 Literature review

In order to assess the sustainability of the EnDev hydropower component in Mozambique and to be able to answer the first research question presented in Section 1.2, it is necessary to explore on what the sustainability concept means and entails. This section reviews what the technical literature says about sustainability and how its assessment should be addressed.

The concept of sustainability has a long history in the intellectual spheres. Its origin is related to the idea of "steady state" or "stationary" economy utilized by some economists in the XIX century. This concept denoted an equilibrium state between production and natural resources; with the idea of avoiding the total depletion of the latter (Hueting, 1998).

Later during the XX century the notion of "equilibrium" was extended, considering as well other aspects of the environmental and social issues. It was with the report "Our Common Future" in 1987 that the concept of sustainability was defined in the way it is commonly understood nowadays, linking it to the issue of intergenerational equity: *"sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (World Commision on Environment and Development, 1987).

The notion of sustainability continues to be debatable regarding to what it precisely entails; nevertheless there is broad agreement that sustainability involves not just the economical conditions, but also the underlying ecological and environmental systems in which economic activity is embedded, and the larger social system of which the economy is a part (Toman, 1998).

This relatively broad understanding of the concept leaves open several interrelated questions related to the measurement and assessment of sustainability. The main debate refers to the relationship between sustainability and measures of economic well-being. Several authors argue that conventional measures of economic welfare or surplus do not seem to adequately capture important dimensions of sustainability, such as social equity or other values that are difficult to express in monetary terms (Toman, 1998). This reasoning leads to the idea that multi-criteria approaches are the best way to address the measurement and assessment of sustainability (Pohekar, 2004). Authors addressing the sustainability issue argue on the well-known three dimensions of sustainable development: economic, environmental and social. Thus the assessment of the sustainability notion of a project, situation or initiative involves the analysis of these principles of sustainable development – i.e. whether due account is taken of the interests of the economy, society and the environment as well those of present and future generations (DuPasquier, 2008).

The general aim when analyzing the sustainability of a project is to assess the effects of a project over time and space, on the basis of sustainable development dimensions – in other words, its impact in the short and long term on the economy, society and environment of a given territory, whether local or global (DuPasquier, 2008).
Nevertheless when the sustainability assessment refers to projects implemented through international cooperation in the developing world – as is the nature of the EnDev programme – the aim has a slightly different perspective, as the main purpose of the assessment in this case is to ensure that the institutions supported through programmes and the benefits realized are maintained and continue after the end of the programme intervention (International Fund for Agricultural Development (IFAD), 2008). Thus the concept of sustainability is extended to incorporate institutional or management sustainability, which is achieved when prevailing structures and processes have the capacity to continue their functions over the long term (Lockwood, 2003).

In this way, the manner in which sustainability is defined is crucial for setting the parameters which are later used for measuring it and understanding the factors that either contribute to, or work against, the sought sustainability. But here there is a problem for the objective quantification of sustainability since different people, or groups of people, governments, local private sector companies, research institutions, etc. have different perceptions of sustainability based on the relative value of achieving their various goals (Hodgkin, 1994). Hence, each organization may choose to look at sustainability from a different perspective and attach significance to different aspects.

2.1 How to address the sustainability assessment of international cooperation programmes

For the majority of donor agencies committed to bringing sustainable and affordable energy into developing nations, the logical definition of sustainability may be one that addresses the idea of sustained energy access for the intervened communities.

Thus, assessing the sustainability of the EnDev hydropower component being implemented by GIZ/AMES-M in Mozambique means forming a view on how the energising hydropower systems implemented are likely to evolve over time. Therefore for the purpose of this research, the concept of sustainability shall be defined using a definition which describes a development programme as being sustainable "*when it is capable of supplying an appropriate level of benefits during an extensive time period after the withdrawal of all forms of support from the external agency*" (Lockwood, 2003).

Thus, in the context of this research, the previous means that the Mozambican EnDev hydropower initiatives will remain operational and creating the expected benefits in the long term once the EnDev Dutch-German intervention stops in the country, staying in an "equilibrium" operational state once the European donors take away its support.

In this manner, the specialized literature addressing the issue of sustainable development coincides on several key determinants or factors for sustainability. The most common factors are:

- Institutional factors, including policy and external follow-up support.
- Financial factors, including the ability to cover operational costs.
- Technical factors, including design, performance and maintenance issues.
- Community and social factors, including willingness to support projects.
- Environmental factors, avoiding adverse environmental impacts.

Consequently, the literature suggests that multi-criteria analysis considering key determinants like the ones stated above is the most popular way of addressing sustainability assessments (Pohekar, 2004).

On the other hand, when reviewing the technical literature addressing the issue on how to promote sustainable renewable energy technologies (RETs) in Africa, it is possible to recognize the special emphasis on the required local institutionalism to encourage the development and diffusion of RETs:

"The transition towards sustainable energy requires an examination of the African countries policy options, priorities and associated issues as well as the formulation of clear and purposeful plans and actions designed to exploit the abundant renewable energy sources", (Chendo, 1994).

Also crucial for the sustainability of renewable energy initiatives is the availability of qualified human resources and entities since the capacities of the people, organisations, networks and systems determine the project's sustainability (GTZ, 2009).

Thus the adoption, development and diffusion of sustainable RETs in Africa – and in this case in Mozambique – depends on a number of important issues, some financial, some market, others social and institutional (Chendo, 1994); and hence the sustainability assessment of the ongoing EnDev programme and its hydropower component should address all these issues.

The following Table 1 summarizes the literature findings on sustainability for the context of the EnDev hydropower initiatives in Mozambique:

Applicable definition of sustainability	"*a development project is sustainable when it is capable of supplying an appropriate level of benefits during an extensive time period after the withdrawal of all forms of support from the external agency*"
Key factors of sustainability to be assessed	• Local institutionalism: existence of supportive policies and regulations for the diffusion of RETs • Financial factors: availability of financing institutions keen to participate in the development of micro/pico hydropower initiatives. Also the ability of the projects promoted to cover their operational costs. • Technical factors: feasible design, performance and maintenance issues. • Community and social factors: acceptance and willingness to support projects from the side of the beneficiaries. • Technical capacities: availability of qualified human resources and entities for external follow up. • Environmental factors: inexistence of adverse environmental impacts.

Table 1: Summary of the literature findings on sustainability assessment

Thus, the key factors above mentioned determine the sustainability of development projects, and hence should be considered in a multi-criteria analysis when assessing the capability of EnDev projects in supplying the expected benefits in the long term after the withdrawal of all forms of support from the external agencies. The method how these key factors are organised for a sustainability assessment in a multi-criteria analysis is discussed in the next section.

3 Methodology

As it has been described in the Section 1.2, the sustainability assessment of the EnDev hydro component in Mozambique was based on the tool developed by IVM/IS Academy "Sustainability Assessment Framework for EnDev project activities" (SAF-EnDev). This section describes the method used to apply this tool.

The mentioned EnDev framework addresses the sustainability evaluation of energising development initiatives based on four main dimensions:

- ***Enabling environment***, which entails the factors in the macro-environment that influence the dissemination of renewable energy technologies throughout the society.
- ***Consumer behaviour***, which refers to the understanding of the behavioural drivers that impact the household decision-making process regarding the products or services provided.
- ***Enterprise design and business planning***, which aims to determine whether the implemented energising initiatives appear suitable for sustained operation following the conclusion of the EnDev programme support.
- ***Environmental sustainability***, which aims to ensure that adverse environmental impacts are not caused by EnDev activities.

These dimensions summarise the key factors presented in Table 1 in Section 2.1 and consequently are the four crucial pillars for the sustainability of EnDev initiatives.

The SAF-EnDev tool also suggests sub-dimensions, indicators and qualitative assessment questions in order to determine the strength of these four pillars. The following table presents the sub-dimensions considered by the tool for each of these pillars.

Enabling environment	***Enterprise design and business planning***
• Policies and regulations • Local agencies and their role • Partnerships among local agencies and other actors	• Market information • Sales, Marketing, and Post-Sales activities • Financial management • Human resources available for enterprise • Operations of the enterprise
Consumer behaviour	***Environmental sustainability***
• The household capacity • The social environment • User awareness of benefits • Access to consumer goods markets and services	• Environmental sustainability of private enterprises supported by the project

Table 2: Dimensions and sub-dimensions considered by the SAF-EnDev tool for a sustainability assessment

In order to evaluate each of the sub-dimensions presented above the tool suggests indicators and qualitative assessment questions to address the topics posed. In order to score the indicators recommended the EnDev sustainability assessment framework proposes a 4-point scale that allows grading the topics posed for each dimension according to the likelihood of sustainability[12]. The scoring method proposed is:

0 = nothing, no contribution to sustainability;
0.25 = low contribution to sustainability;
0.5 = medium contribution to sustainability; and
1 = high contribution to sustainability.

In this way, each indicator within a sub-dimension receives one of the four possible scores above mentioned; later the indicators' scores of a same sub-dimension are weighted and a single score for the sub-dimension is obtained. The same is done for the sub-dimensions within each of the four main dimensions, obtaining at the end a single score for each of the main sustainability dimensions presented.

This scoring method presented is of a subjective and experimental nature, and its utilisation was requested by NL Agency as a way to try out the SAF-EnDev tool. The weight that each dimension and sub-dimension receives according to its contribution to sustainability is a subjective issue, and therefore in order to simplify the scoring process for the sustainability assessment, all the sub-dimensions belonging to a same dimension proposed by the tool were weighted equally. The same was done for the indicators within the same sub-dimension. In this context, and due to the subjectivity described, in the case of the four pillars for the sustained operation of the hydropower systems, no single score grouping the four main sustainability dimensions was developed and hence the results of the assessment of each of the four sustainability pillars are presented independently in Section 4.

The results obtained from the utilisation of the tool and the scoring method here described should be understood as the output of an explorative research that aims to test the sustainability assessment framework developed by IVM/IS Academy, and at the very end, seeks to improve the sustainability of the EnDev projects.

3.1 Research methods

The research was based on a field work performed during six weeks in Mozambique during the months of June and July 2011. It utilised two semi-structured methods of qualitative nature to address the assessment of the four main dimensions already mentioned: focus groups discussions[13] (hereinafter FGDs) with consumers and beneficiaries of EnDev hydropower systems operating, as

[12] For more details on the tool, indicators, qualitative assessment questions suggested, and the scoring method here described please refer to the first version of the document "Sustainability assessment framework for Energising Development projects activities" (Barua, 2011).

[13] Focus group discussion is a group situation in which the participants talk with one another under the guidance of a moderator. Each participant is stimulated by the comments of others and in turn stimulates them. It has the purpose of generating relevant ideas and information (Kumar, 1987).

these are a qualitative method that generates a rich understanding of participants' experiences and beliefs (Morgan, 1998); and interviews with local governmental and private entities involved in the development of energy generation initiatives in the country and also with owners of hydroelectric systems implemented by the EnDev programme.

The reasons for choosing a qualitative research approach stem from an intention to discover insights about the strengths of the four sustainability pillars suggested by the SAF-EnDev tool. The methods used in the research are of exploratory nature and this is due to the originating reason entrusted by NL Agency, which is to test the EnDev sustainability framework finalised in a first version in March 2011. The testing of the SAF-EnDev tool is part of a "*learning by doing*" process and hence justifies the explorative nature of the methods applied.

Qualitative data from FGDs with consumers and beneficiaries of hydropower systems was the main source of information to address the *Consumer behaviour* dimension of the SAF-EnDev tool, meanwhile the information gathered during the interviews was the main source to address the remaining three pillars of the tool: *Enabling environment*, *Enterprise design and business planning*, and *Environmental sustainability*. Also key information was collected during informal interviews with those responsible for the EnDev programme at GIZ/AMES-M.

It is important to note that qualitative research does not allow the collection of disaggregated data differentiating between more and less dominant views; they nevertheless allow extracting the variety of possible explanations for the meanings behind the observed trends and to identify key issues. Consequently, the findings and final suggestions of this research should be read as a picture of possible ways to improve the sustainability of the EnDev hydropower systems already operating in Mozambique, and also the sustainability on the ones that will be implemented in the future.

3.2 Adaptation of the Sustainability Assessment Framework for EnDev project activities

The SAF-EnDev tool developed for NL Agency by IVM/IS Academy is a generic framework aiming to address the sustainability issue of a diverse type of projects being implemented under the EnDev programme in more than twenty different developing countries in Africa, Asia and Latin America. Even when all the EnDev projects implemented globally have the main original goal – which is to increase the access to energy – they vary in technology utilised, product/service being disseminated, implementation and diffusion strategy, enterprise design and business model, and naturally in the characteristics of the host country and local conditions. Hence the SAF-EnDev tool is a guideline on how a sustainability assessment should be addressed, but it should be adapted according to the nature of the EnDev intervention that is being assessed.

For example in the case of the hydropower plants being implemented in Mozambique under the EnDev programme by GIZ/AMES-M, the benefit that consumers receive is access to electricity, and hence needs a different approach to a situation where the consumers/beneficiaries from another EnDev initiative receive a tangible product, like solar lanterns for instance.

Consequently, the original version of the SAF-EnDev was adjusted for the purpose of this research. The adjustments made to the tool are described in the next section and the final version utilised is presented in Annex II of the report. The main adjustments were made in the section of the tool addressing the *Consumers behaviour* and *Enterprise design and business planning* dimensions. This is because the original SAF-EnDev tool is quite oriented towards consumers of products (i.e.: solar

lanterns, improved cooking stoves, etc) and formally constituted enterprises. In the case of the EnDev hydropower component assessed in Mozambique the benefit being provided to consumers is the access to electricity, benefit that for the purpose of this research is understood as a service[14].

3.2.1 Similarities of the hydropower systems regarding the dimensions of the EnDev Sustainability Assessment Framework

The EnDev hydropower component in Mozambique is being implemented by GIZ/AMES-M in different phases as it has been described previously in section 1.3.1. Each EnDev phase has a certain strategic approach for implementation and operation; meaning this that all the hydropower systems implemented during a certain EnDev phase follow a similar pattern.

At the same time, the SAF-EnDev tool works based on the four main pillars or dimensions presented at the beginning of Section 3.

Thus, given that the hydropower systems implemented during the same EnDev phase follow a similar pattern, its business model and financial design is analogous and therefore the assessment of the *Enterprise design and business planning* dimension of the SAF-EnDev tool is common to all the hydropower systems implemented during the same phase.

Simultaneously, the role of governmental institutions, supporting agencies and policies involved in the promotion and implementation of micro and pico hydropower initiatives in Mozambique is similar to all the systems implemented by the EnDev programme, and hence the assessment of the *Enabling environment* and *Environmental sustainability* dimensions of the SAF-EnDev tool is again common to all the hydropower systems implemented by GIZ/AMES-M.

This means that for a group of hydropower systems implemented by GIZ/AMES-M during a same EnDev phase, the assessment of the *Enabling environment*, *Enterprise design and business planning*, and *Environmental sustainability* dimensions of the SAF-EnDev tool, is similar to all the systems. Therefore only the *Consumer behaviour* dimension of the EnDev sustainability framework was gauged independently for the specific hydropower systems assessed during the field work.

3.2.2 Content Framework

The SAF-EnDev required adjustments in some of its dimensions in order to make it applicable to the nature of the hydropower projects assessed. Some of the sub-dimensions were left out since they were not in line with the characteristics of the projects. This section describes the content framework of the EnDev tool adjusted for sustainability assessment in Mozambique.

[14] Services are economic activities offered by one party to another. Often time-based, performances bring about desired results to recipients, objects, or other assets for which purchasers have responsibility. In exchange for money, time, and effort, service customers expect value from access to goods, labor, professional skills, facilities, networks, and systems; but they do not normally take ownership of any of the physical elements involved (Lovelock, 2008)

For the *Enabling environment* dimension no major adjustments were required. The interviews addressing this dimension of the SAF-EnDev focused on the following issues:

Enabling environment topics addressed during interviews:

- Policies and regulations for the renewable energy sector.
- The local agencies supporting the development of the renewable sector and their role.
- Partnerships among local agencies and other actors supporting the promotion of renewable energies

In the case of the FGDs addressing the *Consumer behaviour* dimension, the discussions addressed the issues of:

Consumer behaviour topics addressed during the FGDs:

- User awareness and benefits of access to electricity.
- Household economy and capacity to afford energy fees and purchase of appliances.
- Social environment.
- Beneficiaries satisfaction with the service provided.
- Social acceptance.
- Access to consumer goods market and services.

In the case of the interviews addressing the *Enterprise design and business planning*, and *Environmental sustainability* dimensions of the SAF-EnDev tool the questions addressed the following issues respectively:

Enterprise design and business planning topics addressed during interviews:

- Utilisation of market information in the business design.
- Sales, marketing and costumers services activities.
- Financial management of the hydropower generation business.
- Operation of the hydropower plants.

Environmental sustainability topics addressed during interviews:

- Environmental sustainability of the hydropower systems operating.

Details of the design of FGDs and interviews are presented in the next section of the report.

3.3 Fieldwork design

The following sections describe the design of the fieldwork activities and reasons for the choices made.

3.3.1 Selection of EnDev hydropower systems assessed

As it was described in section 1.3.1, the hydropower component of AMES-M counted initially on a pilot phase, EnDev I, where four hydropower systems were implemented during the period 2007-2009 in the community of Chua[15] in Manica province.

A second phase, EnDev II, was initiated during the second half of 2010 also in Manica province and followed the pilot phase. This second phase should finalise in December 2012 and at the time of the field work developed in Mozambique for this research (June-July 2011), no hydropower systems of the EnDev II phase were fully operational. The most advanced ones were in the communities of Sussundenga and Chitunga, where the systems had already been generating electricity for a few months before, but the households in the community were not yet connected to the mini-grid as a whole and hence it was decided with GIZ not to assess the sustainability of the hydropower system belonging to the phase EnDev II as it was too soon to do so.

Therefore, in order to answer the first of the research questions presented previously in section 1.2 of the report, it was determined jointly with GIZ to assess the sustainability of the hydropower systems implemented in the community of Chua during the EnDev I phase, given that those systems have been operating since 2009 and therefore were the only ones with enough historic operational time to assess the electricity users attitude through FGDs in order to address the *Consumer behaviour* dimension of the SAF-EnDev tool.

In this context, and as it has been mentioned already – and is also described in detail in Annexe I – the EnDev I pilot project in Chua counts on four hydropower systems. The systems are identified according to the name of their owner/operator[16] as the following table shows:

[15] For more details on the Chua pilot project of the EnDev I phase please refer to Annex I of this report.

[16] The owner of the hydropower systems is who operates the system and provides electricity to the consumers, hence it is also called "operator".

System identification in Chua community according to the mini-grid operator name	Installed capacity of the hydropower system	N° direct connections per hydropower system[17]		
		Households	Shops	Total
Lino Ndacada	20 KV	35	8	43
Benjamin E. Mucheca	18KV	28	1	29
Arao J. Pondo	18KV	37	7	44
Tomas W. Nguarai	20KV	36	3	39
Total N° of connections in the four Chua hydropower systems		136	19	155

Table 3: Details of the hydropower systems in Chua

Given that these four systems are part of the same EnDev phase and hence share the same pattern, it was agreed with GIZ/AMES-M and AKSM, the NGO responsible for the implementation of the EnDev hydropower systems, to organise FGDs with consumers for only two of these systems. It was agreed that a sample of half of the EnDev hydropower operational plants was enough to get a good idea of the *Consumers behaviour* towards the hydropower projects in order to assess the sustainability of the systems of the phase EnDev I as a whole.

The selection of the EnDev systems in Chua for FGDs was done jointly with AKSM and it was based on the accessibility to the hydropower projects and the households connected to it. As it is described in Annexe I, Chua is a rural community located at the mountains that border Zimbabwe. The community is stretched out over two valleys and the surrounding mountains. Families live very distantly from each other and the access roads are precarious. Therefore the hydropower systems selected to develop FGDs with its consumers were those with best accessibility. The two systems selected were:

- Lino Ndacada's system; and
- Tomas W. Guarai's system

3.3.2 FGDs design and selection criteria of respondents

Two FGDs were designed for each of the hydropower systems selected. The target participants of the FGDs aiming to address the *Consumer behaviour* dimension of the SAF-EnDev were adult household members that had connection to the mini-grid system powered by one the EnDev hydroelectric systems selected. No distinction of gender was made. The only requisites for participation during the FGDs were:

- To be adult;
- To have direct electricity connection at home provided by the EnDev mini-grid powered by the hydropower system being assessed (either Lino Ndacada's or Tomas W. Guarai's).

[17] Figures reported by AKSM in January 2010.

The four FGDs were executed in the local dialect *Shona* since for a large percentage of Chua community's population it is the only language spoken. A *Shona-English-Portuguese* translator recommended by the AKSM was hired and played a crucial role during the FGDs.

The FGDs were designed to have 7-10 respondents each and a previous invitation process was organised for each of the FGDs dates. The FGDs guideline utilised by the translator is presented in Annex III.

3.3.3 Entities selected for interview, criteria for selection and design of the interviews

In order to tackle the *Enabling environment, Enterprise design and business planning*, and *Environmental sustainability* dimensions of the SAF-EnDev tool several entities were selected for interviews. The entities selected were located in Manica town, Chimoio city (capital of Manica province) and Maputo. The next table lists the entities interviewed and gives a description of the reason for selection:

Entity	Location	Reason of selection
AKSM	Manica town	NGO contracted by GIZ for the implementation of the hydro component of the EnDev programme.
Banco Terra	Chimoio	Signed an agreement with GIZ to partially finance hydropower systems under the EnDev programme.
Metalurgica	Chimoio	Firm manufacturing turbines and other parts for the EnDev hydropower systems.
DIPREME	Chimoio	Provincial Authority of Energy and Mineral Resources.
Instituto Superior Politecnico de Manica (ISPM)	Chimoio	Institution of higher education based in the capital of Manica province.
Universidad Pedagogica Chimoio (UP)	Chimoio	Institution of higher education based in the capital of Manica province.
Universidad Catolica de Mozambique (UCM)	Chimoio	Institution of higher education based in the capital of Manica province.
Escola de Artes e Oficios (EAO)	Chimoio	Institution of higher education based in the capital of Manica province.
FUNAE	Maputo	National Fund of Energy – dependent from the Ministry of Energy.
GIZ/AMES-M	Chimoio	Responsible of the EnDev intervention in Mozambique.

Table 4: Entities interviewed during the field work in Mozambique

The interviews were designed to cover the topics suggested by the SAF-EnDev guidance for the *Enabling environment, Enterprise design and business planning*, and *Environmental sustainability* dimensions. The topics addressed with each of the entities interviewed are detailed in Section 4.

3.4 Fieldwork process and limitations

The following sections describe the process of the fieldwork and limitations encountered.

As it has been mentioned earlier, the field work took place for six weeks in Mozambique during the months of June and July 2011. The FGDs were organised and performed during the first three weeks of the period in the community of Chua. The interviews were executed during the last three weeks of the field work in Manica town, Chimoio and Maputo.

The invitations to the FGDs were executed personally by the researcher visiting the community accompanied by the system owner/operator and the translator. The households were selected randomly jointly with the system owners. The invitation process took one or two days for each of the FGDs due to the distances between the households of Chua community and was developed two or three days before the FGDs took place. The invitations tours were done by walking through the tracks existing in the valley of Chua given the lack of roads for vehicles.

Per each of the FGDs, 10 invitations were made, 8 for households and 1 or 2 for shops. The invitations were made to only one adult member of the family/shop, meaning this that in total forty adults were invited, ten for each of the four FGDs developed, covering 26% of the 155 total connections (households and shops directly connected to the system) reported in Chua by AKSM in January 2010 (for details on the figures reported by AKSM see Annex I).

The FGDs had 90% assistance with respect to the invitations given, with 36 people participating in total during the four FGDs executed, a figure that counts for 23% of the total households and shops directly connected.

Some basic details were gathered from the respondents that participated in the FGDs. The following table summarises in figures the FGDs and the characteristics of the participants.

N° of participants FGDs 1 Lino Ndacada's system	8 people	6 HH; 2 shops
N° of participants FGDs 2 Lino Ndacada's system	11 people	9 HH; 2 shops
N° of participants FGDs 1 Tomas W. Guarai's system	8 people	6 HH; 2 shops
N° of participants FGDs 2 Tomas W. Guarai's system	9 people	8 HH; 1 shop
Total N° of participants in the four FGDs	36 people	
Average age of respondents	44 years	
Average N° of years of education	5.3 years	
Average N° of people living in the household of the respondent	10 people	
Percentage of respondents per gender: 73% male; 27% female		

Table 5: Details on the FGDs performed and participants

The FGDs were organised to last 1.5 to 2 hours and were always conducted in *Shona* by the translator using the same FGD facilitator guideline. They had 8-11 participants and translation to English was done after discussing each of the topics addressed in the guideline. After each FGD refreshments were offered to the participants and informal discussions took place.

In all the FGDs the conversations were recorded. Also notes were taken on each topic addressed according to the translation of the translator.

The FGDs were performed in the open air somewhere close to the hydropower system being assessed. Given this situation it was impossible to avoid others inhabitants of the community getting close, sitting and observing the discussions.

Regarding the interviews conducted, these ones were developed in Portuguese and usually lasted around 30 minutes.

The outlined set-up of the fieldwork process resulted in several limitations with respect to the content:

- The use of *Shona* language for the FGDs conducted made it impossible for the author to directly understand the discussions, meaning this that all the ideas and arguments given by the participants during the FGDs were filtered by the translator.

- The FGDs addressed the topic on the economy of the households; this topic is sometimes not an easy one to address with respondents that receive benefits from donors. Hence the data gathered on this matter should be taken with a grain of salt.

- Given the governmental hierarchies and local cultural characteristics some respondents of governmental entities interviewed might had given "*polite answers*" as a policy of their organizations.

4 Results

This section addresses the first of the research questions presented previously in section 1.2 regarding the sustainability of the hydropower systems implemented in Mozambique by the EnDev programme. The other two research questions regarding how both the SAF-EnDev tool and the sustainability of EnDev hydro intervention could be improved are addressed in Sections 5 and 6 of this report respectively.

4.1 To what extent are the EnDev hydropower systems implemented in Mozambique sustainable?

As it has been mentioned formerly, this question was addressed using the "Sustainability Assessment Framework for EnDev project activities" developed by IVM/IS Academy.

The answer to this question is based on the analysis of the four pillars for sustained operation presented previously in section 3:

- *Enabling environment*;
- *Consumer behaviour*;
- *Enterprise design and business planning*; and
- *Environmental sustainability*.

Thus, the sustainability of the hydropower systems implemented during the EnDev I pilot phase is analysed in this section separately for these four dimensions in the first instance. For all of the sub-dimensions considered in each of the main four dimensions above, indicators and qualitative assessment questions were utilised to obtain a general view of sustainability as it was described at the beginning of Section 3.

This section presents a summary of the details gathered for each of the four main pillars. At the end of the analysis for each of the four pillars a table showing the qualitative assessment questions utilised and summarising the scores of each indicator, sub-dimension and the final score for the dimension is presented. In Annex V a detailed description of the findings for each sub-dimension and indicator is presented.

In the last part of this section a general overview of the sustainability of the hydropower systems analysed is presented in Section 4.1.5.

Also some preliminary thoughts on the sustainability of the EnDev II phase are presented in Section 4.2.

4.1.1 Sustainability of the EnDev hydropower systems according to the local enabling environment

The *Enabling environment* for the promotion of micro/pico hydropower systems in Mozambique was addressed focusing on three main aspects – or sub-dimensions – that create a favourable atmosphere for the development of this type of initiative according to the SAF-EnDev tool; these are:

- *Policies and regulations*;
- *Local agencies and their role*; and
- *Partnerships among local agencies and other actors*

As it was described in Section 3, these issues were addressed through interviews with different entities holding a stake in the field of renewable energy, specifically in micro/pico hydro generation.

Findings:
The policy framework existing in Mozambique for the promotion of RETs in general is still weak. In the case of micro/pico hydropower technologies, the local government has only recently started recognising its potential. No national or regional governmental programmes exist for the diffusion of RETs and only programmes from external donors exist in this field (i.e.: the Dutch-German EnDev programme).

The local RETs sector lacks of actors with knowledge and experience to support the development of the market; this is in both, the governmental and private spheres. The RETs issue is a new field in the country and needs further development from both, the policy side that generates the required incentives to develop the sector; and the private/financing side that leverage the development and diffusion of the RET markets. More motivating factors should be put in place by the Mozambican government in order to attract investments that increase the national energy access figures.

In the context of micro/pico hydropower generation, GIZ/AMES-M has been basically the only entity working in the implementation of this type of initiative and building the capacities for the development of the market. Only recently – in the last 18 months – the energy authority in Manica province, DIPREME, has initiated cooperation efforts together with GIZ/AMES-M and FUNAE to promote the diffusion of micro/pico hydropower initiatives in the province. Apart from that, no others partnerships for the development of the micro/pico hydropower sector exist in the country.

Thus, given the information gathered during the field work, the *Enabling environment* dimension received a final overall score of 0.32, which according to the scoring systems proposed by the SAF-EnDev tool means a contribution to sustainability between low and medium. The table in the next page summarises the scores given for indicators and sub-dimensions of the *Enabling environment* pillar. Details on the findings and qualitative assessment of the indicators are presented in Annex V of this report.

EEA	Enabling Environment Adapted (EEA)	Final EEA score	0,32
EEA1	**Policies and Regulations**	**EEA1 score**	**0,33**
		EEA1 weight	0,33
EEA1.1	**Presence of supportive policies and regulations to enable the diffusion of RETs**	**EEA1.1 score**	**0,50**
N° of questions 1	1. Are there government polices currently in place that support the diffusion of renewable energy technologies?		
EEA1.2	**Presence of national and regional programs supporting the diffusion of RETs**	**EEA1.2 score**	**0,50**
	1. Are there local/regional government programs for the training and development of RET technicians and entrepreneurs?		
N° of questions 3	2. Are there national or regional programs for the development of RET markets?		
	3. Is renewable energy incorporated into development and poverty reduction strategies?		
EEA1.3	**Presence of clear motivating factors for use of RETs**	**EEA1.3 score**	**0,00**
N° of questions 2	1. Is there a target set by the government in relation to the use of renewable energy in the future?		
	2. Are there complimentary policies, such as environmental regulations in favour of RETs?		
EEA2	**Local agencies and their role**	**EEA2 score**	**0,38**
		EEA2 weight	0,33
EEA2.1	**Capacity of local market institutions and supportive actors**	**EEA2.1 score**	**0,25**
	1. Do RET agencies (local/regional) have sufficient capacity and resources to support the use of renewable energy?		
	2. Are energy policy and RET issues available in technical and vocational school curricula?		
N° of questions 4	3. Is the promotion of RETs supported at all levels of government?		
	4. Are local needs, in relation to the technology in focus, timely articulated by the relevant bodies?		
EEA2.2	**Availability of technology diffusion support systems**	**EEA2.2 score**	**0,50**
	1. To what extent are technology extension services being provided?		
	2. Are there maintenance technicians (private entrepreneurs or also public employees) at the local level providing adequate services?		
	3. Are there graduates (technicians) from vocational and technical training institutions related to renewable energy technologies?		
N° of questions 5	4. Are there micro-credit institutions readily accessible to potential energy technology users?		
	5. Are there cost sharing schemes currently in place to support the use of RETs?		
EEA3	**Partnerships among local agencies and other actors**	**EEA3 score**	**0,25**
		EEA3 weight	0,33
EEA3.1	**Presence of civic societies and associations**	**EEA3.1 score**	**0,25**
	1. Are there strong partnerships among various stakeholders with a shared commitment in the promotion of renewable energy technologies?		
N° of questions 3	2. Are there associations of enterprisers and technology users?		
	3. Are there advocacy groups providing legitimacy to the technology at various levels?		

Table 6: Summary of the scores obtained by the Enabling environment dimension

4.1.2 Sustainability of the EnDev hydropower systems according to the consumer behaviour

The *Consumer behaviour* dimension was assessed through FGDs with beneficiaries of the EnDev micro/pico hydropower systems operating in Manica province as it was described in Section 3. The assessment was focused on four main aspects – or sub-dimensions – that describe the attitude of the consumers towards the electricity service being provided by the EnDev intervention and hence help to form an idea of acceptance and value given by the beneficiaries to the projects. The sub-dimensions addressed are:

- *The household capacity*;
- *The social environment*;
- *User awareness of benefits;*
- *Access to consumer goods markets and services;*

Findings:
During the FGDs it was possible to gather that the beneficiaries of the EnDev intervention in Chua have knowledge on basic uses of electricity (lighting, TV, radio, cooling, etc.); nonetheless, very few activities of productive use of energy are yet implemented. At the same time, the households have a positive attitude in regard the flat fee being charged for the energy service; however, the fee amount is between 40-70% of the money available at home monthly; this is explained due to the fact that Chua inhabitants practice mainly a subsistence economy without requiring money in their diary life, and now the electricity access requires from them a monetary commitment that was non-existent previously.

On the other hand, even when the access to electricity has changed some of the habits of the beneficiaries (they now spend more time at home watching TV, listening radio, etc.), they enjoy this changes and do not see them negatively. Actually, the fact of having electricity at home is seen very positively by the society and Chua inhabitants agree that the EnDev hydropower systems bring tremendous benefits to the community. Also, special importance is given by Chua inhabitants to the Revolving Fund established by GIZ/AMES-M along with the EnDev hydropower systems[18].

Alternatively, even when the consumers are happy with the access to electricity benefit and they can find all type of appliances and associated services in the markets of Manica town, they already recognise some technical problems with the energy supply that have not been solved; these are related to the level of electric current. This aspect should be reviewed by GIZ/AMES-M and AKSM.

Consequently, given the information gathered during the FGDs and presented in detail in Annex V, the *Consumer behaviour* dimension received a final overall score of 0.78, which according to the scoring systems proposed by the SAF-EnDev tool means a contribution to sustainability between medium and high. The table in the next page summarises the scores for indicators and sub-dimensions of this dimension.

[18] For more details on the Revolving Fund please refer to Annex I.

CBA	Consumer behaviour Adapted (CBA)	Final CBA score	0,78
CBA1	**The household capacity**	**CBA1 score**	**0,63**
		CBA1 weight	0,25
CBA1.1	**Knowledge and skills levels of consumers regarding the use of electricity**	**CBA1.1 score**	**0,50**
N° of questions	1. Does the target group posses the skills needed to correctly use the electricty		
2	2. Does the programme provides skills training to the consumers		
CBA1.2	**The hydropower systems implemented are in line with the household labour economy**	**CBA1.2 score**	**0,50**
N° of questions	1. The consumers experience a gain in labour time through the technology adoption?		
1			
CBA1.3	**The household financial capacity corresponds to the cost of electricity**	**CBA1.3 score**	**1,00**
	1. What is the willingness to pay?		
N° of questions	2. How does the cost of electricity relate to income levels?		
3	3. Do households generate extra income thanks to the electricity access?		
CBA1.4	**The household owns the physical capital needed**	**CBA1.4 score**	**0,50**
N° of questions	1. Is the electricity provided compatible with the living conditions of the majority of consumers?		
2	2. To what extend is the access to electricity provided compatible with the household existing resource endowment?		
CBA2	**The social environment**	**CBA2 score**	**1,00**
		CBA2 weight	0,25
CBA2.1	**The technology is in line with existing norms, values and cultural preferences**	**CBA2.1 score**	**1,00**
N° of questions	1. Does the technology comply with cultural practices and preferences?		
2	2. Does the technology demand a change in existing habits from the household and if so how does it impact their traditions?		
CBA2.2	**The technology is accepted by the society**	**CBA2.2 score**	**1,00**
N° of questions	1. Do households gain prestige within the community when having access to electricity (creation of socio-economic status)?		
2	2. How does the community value the technology?		
CBA3	**User awareness of benefits**	**CBA3 score**	**0,50**
		CBA3 weight	0,25
CBA3.1	**Consumer awareness of the benefits of having electricity access**	**CBA3.1 score**	**0,50**
N° of questions	1. Are households aware of the advantages of having access to electricity?		
1			
CBA3.2	**Consumers are satisfied with the electricity service being provided**	**CBA3.2 score**	**0,50**
N° of questions	1. Have the consumers experienced problems with the electricity supply?		
2	2. How often do the consumers experience problems with the electricity supply?		
CBA4	**Access to consumer good markets and services**	**CBA4 score**	**1,00**
		CBA4 weight	0,25
CBA4.1	**Appliances for the use of the electricity are accessible by the household**	**CBA4.1 score**	**1,00**
	1. How much does a household need to spend on acquiring appliances?		
	2. Do local markets offer appliances?		
N° of questions	3. What is the distance to the nearest market?		
4	4. How reliable is the appliance market?		
CBA4.2	**Access to maintenance services**	**CBA4.2 score**	**1,00**
N° of questions	1. Can consumers easily access maintenance support in case of a technical problem?		
1			
CBA4.3	**Accessibility of the technology**	**CBA4.3 score**	**1,00**
N° of questions	1. Are there alternative technologies/fuels available and what is the relative price difference?		
1			

Table 7: Summary of the scores obtained by the Consumer behaviour dimension

4.1.3 Sustainability of the EnDev hydropower systems according to the enterprise design and business planning

As it was described in Section 3, the *Enterprise design and business planning* of the EnDev hydropower systems being implemented in Manica province was assessed through interviews with entities involved in its implementation, and also with the project owners/operators. In line with the SAF-EnDev guideline, the issues considered for the analysis of this dimension were:

- *Market information;*
- *Sales, marketing and customer service activities;*
- *Financial management;* and
- *Operation of the projects.*

These sub-dimensions have a slightly different approach to the original version of the SAF-EnDev tool. For more details on the adaptation of the tool please refer to Annex II.

Findings:

During the field work it was possible to gather that a study on energy use and socio-economic conditions of Chua village was used during the design of the EnDev I phase. Apart from that report, no other baseline studies have been developed in communities where the EnDev programme will intervene during the second phase in Manica province. Additionally, for the generation systems operating in Chua, no monitoring programme, customer service and/or consumer information collection mechanism was in place at the time of the field work for this research.

In terms of financial sustainability, for the implementation of the pilot project in Chua only basic incomes/costs and repayments analysis were performed by the EnDev promoters during the design of the initiative. In this context, as it has been mentioned earlier and it is described in detail in Annex I, the consumers of the systems in Chua pay a low flat tariff for the electricity consumed (no flexible payment mechanisms are in place); however, when the incomes figures of the owners/operators are analysed along the figures of the repayments to the Revolving Fund, these are rather low. From a report of AKSM dated in April 2010 it was possible to obtain that the income for owners/operators in Chua from payments for energy use was on average only 35% of what they should have received by that time according to the business design.

This last fact in regard the ability of the consumers to pay for the electricity supply is crucial for the sustainability of the EnDev II phase since a local bank shall get involved in the financing of the EnDev systems.

Consequently, given the information gathered during the field work and presented in detail in Annex V, the *Enterprise design and business planning* dimension receives a final overall score of 0.36, which according to the scoring systems proposed by the SAF-EnDev tool means a contribution to sustainability between low and medium. The table in the next page summarises the scores for indicators and sub-dimensions of this dimension.

EDA	Enterprise design and business planning Adapted (EDA)	Final EDA score	0,36
EDA1	**Market information**	**EDA1 score**	**0,50**
		EDA 1 weight	0,25
EDA1.1	**Consumer information is used for business planning**	**EDA1.1 score**	**0,25**
	1. Have market studies including comprehensive consumer data been performed by the enterprise or other organizations?		
N° of questions	2. Does the enterprise have an ongoing mechanism for collecting, monitoring, and responding to consumer and product data?		
3	3. Have the project promoters used consumer data to improve business planning?		
EDA1.2	**Technology usability information is collected through field testing**	**EDA1.2 score**	**0,25**
	1. Has the project promoters conducted a pilot activity for field testing?		
N° of questions	2. Has the project promoters adjusted the projects design/strategy based on greater knowledge of projects performance?		
3	3. Is feedback collected on the technology performance?		
EDA1.3	**Level of regulatory knowledge held by project promoters is increased**	**EDA1.3 score**	**1,00**
N° of questions	1. Do the promoters have developed a network with regulatory officials and advisers?		
2	2. Are the planned activities of the EnDev promoters aligned with national energy policy and planning goals?		
EDA2	**Sales, Marketing, and Costumer Services activities**	**EDA2 score**	**0,38**
		EDA 2 weight	0,25
EDA2.1	**Sales, marketing, and costumers service activities leverage trust and social networks**	**EDA2.1 score**	**0,25**
N° of questions	1. Do the owners/operators and/or the EnDev promoters perform sales, marketing and customer service activities?		
1			
EDA2.2	**Payment and finance mechanisms established are supportive of sustained system operation**	**EDA2.2 score**	**0,50**
N° of questions	1. Does the owner/operator employ flexible consumer payment mechanisms (such as pre-paid cards or fee-for-service payments)?		
2	2. Have the EnDev promoters partnered with local financial institutions to develop lending products for energy services?		
EDA3	**Financial management**	**EDA3 score**	**0,33**
		EDA 3 weight	0,25
EAD3.1	**The EnDev projects are able to recover start-up and operational costs**	**EDA3.1 score**	**0,25**
N° of questions	1. Have the EnDev promoters performed a financial analysis including IRR, ROI, payback period, and breakeven analyses?		
2	2. Do the prices set allow for full cost recovery?		
EDA3.2	**Scalability of the EnDev hydropower business is financially feasible**	**EDA3.2 score**	**0,25**
	1. Do the EnDev hydropower systems have a business plan?		
	2. Are potential investors positive in considering further investment for expansion?		
N° of questions	3. Have the EnDev promoters considered business risks and risk mitigation for systems expansion?		
4	4. Have the EnDev promoters considered engaging the initiatives in carbon finance?		
EDA3.3	**The design and implementation of subsidies used is supportive of market development**	**EDA 3.3 score**	**0,50**
	1. Does the subsidy effectively increase access for the very poor?		
	2. If a direct subsidy has been used, is there a viable exit strategy?		
N° of questions	3. Does the subsidy affect consumer willingness to pay?		
4	4. Does the subsidy fund trainings and education for entrepreneurs?		
EDA4	**Operations of the hydropower systems**	**EDA4 score**	**0,25**
		EDA 4 weight	0,25
EDA4.1	**Extent of monitoring and quality control**	**EDA 3.4 score**	**0,25**
	1. Is elecctricity use and consumer satisfaction monitored?		
	2. Are the owners/operators trained in monitoring activities?		
N° of questions	3. Are the hydropower plants certified by a quality agency?		
4	4. Have innovations been developed as a result of monitoring activities?		

Table 8: Summary of the scores obtained by the Enterprise design and business planning dimension

4.1.4 Environmental sustainability of the EnDev hydropower systems

The *Environmental sustainability* is also a requisite for the sustained operation on the EnDev hydropower systems implemented. The analysis here was based on the only sub-dimension suggested by the SAF-EnDev tool:

- *Environmental sustainability of the EnDev hydropower systems operating;*

The focus of the assessment for this dimension was to determine if the hydroelectric plants operate in line with the local environmental regulations; the issue was addressed during an interview with AKSM.

Findings:

The EnDev hydropower systems implemented in Chua operate within the environmental regulation existent in the country. No EIA was necessary for the Chua projects given that the systems operate on maize mills that were operating for long time before, thus the new power generation activity did not need an EIA according to the local environmental regulation.

Thus, the EnDev micro/pico hydroelectric plants operating in Chua are in line with the local environmental regulatory framework and therefore received a high score.

Therefore, the operation of Chua's EnDev hydropower systems has a high contribution to the sustainability according to the indicators proposed by the SAF-EnDev tool.

ESA	Environmental sustainability Adapted	Final ESA score	1,00
ESA1	**Environmental sustainability of the EnDev hydropower systems operating**	**EDS1 score**	**1,00**
		ESA1 weight	1,00
ESA1.1	**Environmental impacts of systems' operation**	**ESA1.1 score**	**1,00**
N° of questions	1. Is there a clear environmental regulatory framework for the type of EnDev project being assessed?		
2	2. Has an Environmental Impact Assessment (EIA) been performed for the EnDev hydropower systems operating?		

Table 9: Summary of the score obtained by the Environmental sustainability dimension

4.1.5 Overall view of the sustainability of the EnDev hydropower systems in Chua

After assessing the four crucial pillars proposed by the SAF-EnDev tool it is possible to have a general appraisal of the sustainability of the EnDev hydropower systems operating in Chua and thus answer the first research question stated in Section 1.2

The findings and results of the assessment in terms of the consumers' attitude to the systems and also the environmental sustainability of the hydropower plants are very positive. In regard to the consumers, it was possible to gather that they really appreciate the benefit given by the GIZ/AMES-M through the EnDev programme. Their lives have changed and they seem to be keen to work in an organised and coordinated manner within the community to maintain the systems operating as long as possible.

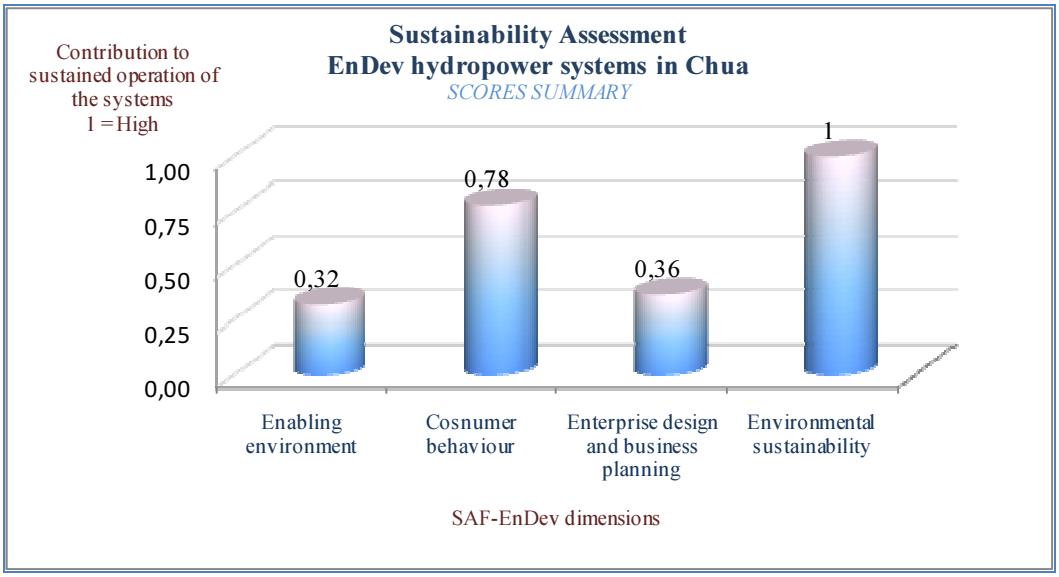
Regarding the environmental sustainability of the systems, these are quite environmentally friendly and the sustained operation should not be threatened by adverse environmental impacts originated by the hydropower generation.

The weakest points for the sustained operation of the hydropower plants are in relation to the enabling environment and the enterprise design and business planning.

According the assessment, from the four dimensions of the SAF-EnDev tool the poorest results are related to the existing local atmosphere for the development of the RETs sector. The main issues here are regarding the existing human capital in the country; Mozambique has a lack of qualified people at governmental and private level to support the diffusion and development of RETs in general. The absence of solid supportive policies for the diffusion of RETs along with the lack of strong advocacy groups of stakeholders pushing for the development of the sector decimate the efforts of individual local entities and international donors that seek the development of the RETs market and the increment of energy access in the country.

On the other hand, the business model of the EnDev hydropower initiatives is not yet proved to be self-sustainable in the long term. The Chua pilot project has proved the technological feasibility of the hydropower plants, but still the design of the EnDev power generation business and enterprise model should be adjusted and perfected according to the characteristics of the local entrepreneurs and consumers being supported by the EnDev programme.

These findings on the SAF-EnDev four main pillars for sustainability above summarised are reflected in the following graph that synthesises the experimental scores given for each indicator and sub-dimension in sections 4.1.1 to 4.1.4.



Graph 1: Summary of the four dimensions' sustainability scorers for the EnDev systems in Chua

The graph presented here above helps to visualise clearly the findings of the field work and to have an idea on the extent to which the EnDev hydropower systems in Chua are sustainable. Notoriously, the atmosphere for the promotion and diffusion of RETs initiatives has to be developed further in order to build a suitable environment that contributes to the sustained operation of the micro and pico hydroelectric initiatives implemented through the EnDev programme.

At the same time, the business model and enterprise design should also be improved by the EnDev promoters. The existence of water resources and technological feasibility has been proven already with the Chua pilot project, but still the business model according to the characteristics of the rural inhabitants being benefited should be strengthened and consolidated for the sustained operation of the hydropower plants.

Accordingly, given the results of the assessment for the four sustainability pillars and the funding characteristics of the hydropower systems in Chua, it is very likely that these will remain operating and providing the expected level of benefits in the long term if the technical problems that might appear are solved correctly. Even when the figures analysed show that the incomes generated by the owners/operators are bellow the expectations – as well as the repayments to the Revolving Fund –, the family run business nature of the systems and the almost non-existent operational costs of the plants will allow the owners to provide electricity to the community without business bankrupt threats. The fact that no collaterals were involved in the financing of the systems, and the eventual low or non-repayments of the "symbolic" loan to the Revolving Fund will not affect any other else than the same community, making very unlikely that the electricity supply could be stopped by the owners/operators of the power plants.

4.2 Preliminary thoughts on the sustainability of the EnDev II phase projects

Even though at the moment of the field work for this research there was not yet EnDev II hydropower systems implemented, it is still possible to make some comments on GIZ/AMES-M strategy and the implementation stage of the second hydropower EnDev phase in Mozambique in order to contribute to the sustainability strengthening of the systems that will be implemented (for details on the EnDev II phase please refer to Annex I).

- First, for the implementation of the EnDev II phase it is still being used the socio-economic baseline developed for Chua community in 2008 for the pilot EnDev I phase. Thus, it is being assumed that all the communities to be intervened in different districts of Manica province have the same socio-economic characteristics of Chua, what is very likely to not be true and it might affect the sustained operation of the projects being implemented during the EnDev II phase.

- Second, the involvement of local financing institutions is a crucial step for the development of the micro/pico hydropower sector in the country and the GIZ/AMES-M alliance with Banco Terra is an important progression for the implementation of the EnDev initiatives. In this context, during the interview held with Banco Terra's representative it was mentioned that the bank has a big interest in supporting this type of power energy generation activity since they see a good potential in this new business line; nevertheless the bank sees important delays from the EnDev promoters in the submission of formal proposals for financing, a fact that causes the bank to presume that the EnDev hydropower promoters have difficulties with the development of the business and implementation plans.

  In this same context, and from the discussions with GIZ/AMES-M, it was possible to gather that AKSM is responsible for submitting the business proposals to Banco Terra in order get the bank's financing. Thus, AKSM is playing a crucial role for the sustainability of the financing strategy for the hydropower systems to be implemented in the second EnDev phase. Hence, this matter should be reconsidered by GIZ/AMES-M since it might be possible that AKSM does not have the skills to develop business proposals according to the formal standards of the private banking systems.

- Third and also related to the financing strategy of the EnDev II phase, from the discussion with Banco Terra it was gathered that the bank perceives that without productive use of energy the EnDev hydropower systems are not profitable and therefore not eligible for finance by the bank. GIZ/AMES-M is aware of this issue and at the time of the field work for this research a business model based on the productive use of energy was being develop by the EnDev promoters in order to apply it to the EnDev II systems that Banco Terra should finance.

  The situation described assumes that it is possible to formulate a business model based on productive use of energy for the rural communities of Manica province that would be interesting enough for the bank to decide to finance it. Nevertheless there is a chance that the business model developed and presented to the bank does not comply with the

requirements of Banco Terra in terms of risks, returns, etc; and hence the bank may refuse to get involved. In such a case the EnDev II financing and implementation strategy would be put in jeopardy, and thus it might affect the sustainability of the EnDev hydropower systems to be implemented.

Thus, with the idea of contributing to the successful implementation and positive long term results of the EnDev intervention in Mozambique, a general comment is that the three issues above described should be reconsidered and rethought in order to make the possible efforts to improve the sustainability of the hydropower systems that shall be implemented during the EnDev II phase.

5 Critical perspective of the SAF-EnDev tool

The utilization of the SAF-EnDev tool on a trial bases for the sustainability assessment of the EnDev hydropower component in Mozambique provided important insights on how the tool could be improved. Thus, this section aims to answer the second research question presented in Section 1.2. Based on the experimental utilization of the tool during the field work, several critical comments and conclusions could be drawn.

- The results of the utilization of the tool depend on subjective appreciations.

The final results of the utilization of the tool will depend largely on the familiarity with the sustainability concept/definition and the experience of the expert/researcher that makes the assessment. Hence, in order to avoid as much as possible subjective appreciation and interpretation on how the tool could be applied and the different dimensions assessed, all possible points of divergent decisions that lead to multiple interpretations, and hence multiple results, should be limited.

- The concept of sustainability and object of assessment should be clearly defined.

The tool defines the concept of sustainability in this manner "*A definition of sustainability provided by .... that fits here defines the term as: "ensuring that the institutions supported through projects and the benefits realized are maintained and continue after the end of the project'*" (Barua, 2011). Yet, it is not clear if the concept of sustainability refers to EnDev project activities itself (like the hydropower plants in Manica province), or of it refers to the new ventures supported by the EnDev programme (like the owners/operators from Chua described in this report). It might be possible to find a situation where an enterprise supported by the EnDev programme has been able to sustain its own operation, but one of the projects activities that the enterprise runs has not. Hence a clarification in the tool with regards to the concept of sustainability and object of assessment would facilitate the understanding of its scope.

- The four dimensions of the tool are significant for the sustained operation of the activities supported by the EnDev programme.

The four dimensions of the tool have been selected correctly. As discussed in Section 2, the dimensions touch on all the aspects which the literature agrees should be considered when assessing the sustainability of development projects. The *Enabling environment*, *Consumer behaviour* and *Enterprise design and business planning* dimensions are appropriately addressed, since they cover the three main groups of stakeholders involved in the operation of a project activity; this is government and advocacy groups, consumers, and the enterprise.

However, the *Environmental sustainability* dimension still requires further development. The dimension currently uses only one indicator (*Environmental sustainability of private enterprises supported by the project* – ES1 of the tool) which does not entail all the potential environmental issues that might affect the sustained operation of EnDev project activities. In the case of the

hydropower plants in Chua for example, the consumers mentioned problems with the voltage of the systems, an issue that could be explained due to the low water flow (section CBA3.2 in this report). Such types of issues that might affect the operation of EnDev initiatives and originate outside the boundaries of the project activity are not yet considered in the tool. On the other hand, the criterion ES1.1 regarding the development of an environmental impact assessment (EIA) is weak. EIAs are usually only performed when the local regulation requires them (like the case of the Chua systems, see section ESA1 in this report), and the environmental institutionalism and regulation framework in developing countries – where the EnDev programme intervenes – is usually weak. Thus, the *Environmental sustainability* dimension of the tool needs to be rethought and further developed.

- The significance and thresholds of indicators in each dimension should be better defined.

The SAF-EnDev tool does not clearly state either the relevance of each indicator within a certain dimension, nor a sustainability threshold. This fact makes the tool challenging to use due to the subjective nature of the scoring mechanism; different people, groups of people or organisations have different perceptions of sustainability based on their own goals (Hodgkin, 1994). At the same time, according to some authors "*a given indicator does not say anything about sustainability, unless a reference value such as thresholds is given to it*" (Lancker, 2000).

Thus, in the current version of the tool, some indicators might appear more relevant for sustainability than others, depending on the characteristics of the project, technology implemented and perspectives of the assessor. For example, the *Consumer awareness of the technological advantages* (CB3.1 in the tool) is relevant for improved cooking stoves, but not relevant for micro/pico hydropower systems.

Also, as an overall comment on the indicators, not all of them can be applied to certain types of projects. For example, the establishment of a distribution network (ED5.2 in the tool) is not applicable to micro/pico hydroelectric projects.

- The assumptions on the nature and characteristics of the projects and enterprises supported by the EnDev programme should be reviewed.

As discussed in Section 3, the EnDev projects implemented internationally vary in technology, product/service, implementation and diffusion strategy, enterprise design and business model, as well as in the characteristics of the host country and local market conditions. As a result, the approach for the assessment of sustainability should vary as well.

As discussed earlier, the hydroelectric plants implemented in Manica province provide the beneficiaries with access to electricity, which is a service. Consequently, the generalised assumption in the SAF-EnDev tool that the projects supported by the EnDev programme are enterprises selling RET products in the market limits the applicability of the tool, and therefore should be reviewed. This assumption is especially restrictive in the *Consumer behaviour* dimension of the tool that directly presupposes the consumption and utilization of products (see Section 2.3 of the tool).

At the same time, the tool presupposes that the EnDev programme supports enterprises with a formal organization, structure and processes; these makes it less applicable to small family business without these mentioned formalities. In the case of the project activities assessed in Manica province, these are owned by rural inhabitants with little formal education and enterprise managerial skills; the operation and structure of the hydropower microenterprises is of a family nature and hence the described assumptions of the tool restrict the assessment. This assumption was especially restrictive for the projects in Chua in regard to the human resources and operation of the venture (see ED4 and ED5 of the tool), where the tool was too sophisticated for the basic structure of the enterprises that were being assessed.

- The qualitative assessment questions should be examined.

The tool suggests several qualitative assessment questions for the evaluation of each indicator; nevertheless the way how some of the questions could be interpreted is unclear. Such questions include:

- "*To what extent are technology services being provided?*" (in EE2.2 of the tool);
- "*To what extent is the current density of the buyer-supplier network?*" (in EE3.1);
- "*Are there strong partnerships among various stakeholders with a shared commitment in the promotion of renewable energy technologies?*" (in EE3.2);
- "*What do you like about the technology?*" (in CB3.2);
- "*N° of distributors on the market?*" (in CB4.1);
- "*What process has to be followed to acquire the technology*?" (in CB4.3).

The answers to such questions are open to subjective appraisal, as it is not clear in the tool how they should be evaluated. Hence this could lead to divergent opinions and therefore assessment.

At the same time, the suggested questions in the tool only assess the existence of certain aspects that enable the sustained operation of the projects (i.e.: presence of supportive policies and regulations, existence of a business plan, presence of advocacy groups providing legitimacy to the technology, etc); but do not actually allow for the assessment of the real contribution these specific items make to the sustainability of the projects. Put simply, a certain enterprise might have a business plan, but it does not mean that the firm will enjoy a sustained operation.

- The method of data gathering should be defined and standardized.

It is not clear in the tool how information should be gathered and which methods should be used. The construction of pre-structured interviews per type of targeted entity and FGD guidelines per type of consumer (of products or services) would facilitate the collection of information and also would allow the comparison of results along the time line for a certain project assessed, as well as the comparison of results between similar EnDev initiatives.

The variety of EnDev project technologies, approaches and objectives makes it complicated to have a generic framework applicable to the diverse types of projects activates. In order to make the applicability of the tool as consistent as possible, the framework should restrict all possible multiple interpretations that might lead to divergent results; in other words, the tool should be as close as possible to a step-by-step manual. This will facilitate the work of the assessor and also make the final results comparable. In this context, the EnDev programme has a very well defined and standardised method to count the number of beneficiaries achieved by the initiative, and hence there is no reason why the sustainability assessment should not be in line with those standardised EnDev methods.

Thus, based on the field testing of the tool and the findings previously described, the suggestions are as follow:

1. Define all the critical concepts that might be open to multiple interpretations (i.e.: sustainability, strong partnerships, etc).

2. Define the types of projects according to their characteristics (i.e.: projects providing household benefits in the form of services, projects providing household benefits in the form of products, projects providing public benefits, etc), and clearly define the boundaries of each type of project.

3. Develop modules within the tool that are applicable to each specific defined project type.

4. Each module should address the four known dimensions of the tool, but be adjusted to the nature and characteristics of the type of projects.

5. The indicators for each dimension within the modules should be selected according to the characteristics of the project type and be clearly defined. The method of assessment for each indicator should also be clearly stated, as well as the method of data gathering.

6. Clearly define the indicator's contribution to project sustainability and define weights within the dimensions. This may be a subjective matter, but at least if the weights are defined, the final results from different assessments will be comparable.

6 Conclusion and Recommendations

This research analysed the sustainability of hydropower projects implemented by the EnDev initiative in Mozambique utilising the recently designed SAF-EnDev tool. This section shows the conclusions of the assessment in Mozambique and gives recommendations on how the sustainability of the EnDev hydropower systems in the country could be improved, answering the third research question stated in Section 1.2 of this study. The conclusions are as follow:

6.1 Conclusions

Firstly, the energy policy framework of Mozambique is still weak in terms of its support of the diffusion of RETs. The local authority has not set clear regulations, inducements and programmes for the energy sector to increase the electricity access through the large renewable energy potential existing in the country. This can be explained by the fact that the current local government lacks the capacity to formulate and implement appropriate energy policies able to generate investments in the energy field. The situation described denotes a need for human capital in the Mozambican energy sector – in both the governmental and the private sphere – that is able to create an atmosphere which encourages the growth of the energy sector and the improvement of local energy access, in order to reduce the national poverty figures.

Secondly, GIZ/AMES-M has achieved a good momentum with the EnDev hydropower initiatives, proving the feasibility of the technology in the country and attracting the attention of the local government, who sees in the micro/pico hydropower sector a good potential to achieve with its own electrification goals.

Thirdly, the EnDev hydropower electrification initiatives – and the Revolving Fund – have been very positively accepted by the community. The beneficiaries in Chua village have experienced an enormous positive change in their lives, which they very much appreciate. However, the figures gathered in regard to the electricity fee and RF instalment payments show that the consumers in Chua have difficulties in complying with the economic commitments made. This is an essential issue that needs further analysis in order to improve the business model and venture design of the hydropower systems to be implemented during the phase EnDev II. In this second phase, GIZ/AMES-M implementation strategy counts on the involvement of a local private bank for the financing of the power generation systems; hence it is fundamental to improve the business model of the hydroelectricity generation ventures, adjusting it to the real socio-economic characteristics of the communities targeted for intervention. It is highly unlikely that any private bank would involve itself in financing development projects, if these projects cannot cover their own operational costs or meet the financial commitments made. Hence, in order to actualise the EnDev II hydropower implementing strategy and to achieve the desired propagation of hydropower initiatives in Mozambique, it is crucial to perfect the business model being utilised.

Fourthly, given the funding characteristics of the hydropower systems in Chua, it is very likely that these will remain operational and providing the expected level of benefits to the beneficiaries in the long term. Even when the economic figures show that the incomes of the owners/operators are bellow the expectations – as well as the repayments to the Revolving Fund –, the family nature of the business and the almost non-existent operational costs of the plants allow the owners/operators

to cover the operational expenses and to continue supplying electricity to the community without threats to the business.

Fifthly, the hydropower systems implemented in Manica province through the EnDev programme are of a very environmentally friendly nature. Nevertheless, other activities being developed in the area where the hydropower systems are located might create adverse environmental impacts (i.e.: pollution of water resources and/or decrease in the water flow available) that could affect the sustained operation of the EnDev plants. Therefore, this issue should be considered and further monitored.

6.2 Recommendations to improve the sustainability of the EnDev hydropower systems

Like the sustainability assessment, the recommendations are given for each of the four dimensions proposed by the SAF-EnDev

6.2.1 Recommendations for the strengthening of the enabling environment

- Continue supporting the local energy authorities with the needed resources to formulate, adopt and implement coherent energy policies that send clear signals to the investment sector, allowing the diffusion of RETs, an increase in energy access and reduction of poverty in Mozambique.

- Increase and formalize the collaborative efforts between international donors and local entities working to improve energy access and encourage the diffusion of RETs in the country. Create partnerships, and standardised methods and procedures along with others donors, in order to facilitate the reporting tasks of the energy authority and homogenise the procedures and formats of the local energy sector.

- Involve more local actors such as educational entities, business consulting firms, engineering firms and micro-financing institutions, in the design, implementation and monitoring of the EnDev hydropower activities, in order to build the required capacities for the development of the RETs sector and the replication of hydropower initiatives in the country.

6.2.2 Recommendations for strengthening the consumers' relationship with the EnDev systems

- Develop a socio-economic baseline analysis for each of the districts/communities subject to intervention by the EnDev programme. The current EnDev II implementation phase utilises a baseline study developed in 2008 for Chua village. It is likely that the new communities to be beneficiaries of EnDev hydropower systems have different socio-economic characteristics, and hence in order to determine their ability to afford for the electricity, a socio-economic baseline study would be required.

- In line with the previous point, despite the Revolving Fund being a good way of creating ownership of the hydropower systems, its design in terms of consumers' solvency, payment

commitments and penalties should be reviewed, in order to help the consumers to comply with the agreed instalments.

- Implement a data collection and monitoring system on the satisfaction of electricity consumers.

- Train owners/operators and consumers on the productive use of energy in order to allow them to increase their income.

6.2.3 Recommendations for strengthening the enterprise design and business model

- Ensure that the legal frameworks of the Mozambican energy and commerce sector recognise the hydropower generation initiatives implemented by the EnDev programme.

- Seek opportunities to integrate the EnDev electrification initiatives with other rural development services (i.e.: improvement of agricultural production, water supply, etc.).

- Improve the business model of the hydropower ventures according to the real socio-economic characteristics of the consumers.

- Measure the electricity generation by the plants and consumption by the households, in order analyse the option of implementing new payment systems (i.e.: fee according to consumption, prepaid cards, etc).

- Implement a water management system for those power plants that have faced operational problems due to the availability of water resources.

6.2.4 Recommendations for strengthening the environmental sustainability

- Develop EIAs for the new plants being implemented.

- Consider making an assessment of other activities in the region that might create environmental impacts that influence the sustained operation of the EnDev systems.

- Consider determining a baseline of carbon emissions and the potential emission reductions created by all the renewable energy initiatives implemented by the EnDev programme in Mozambique. According to the discussion with the GIZ/AMES-M, the reason that has restricted the involvement of the Mozambican EnDev initiatives in the carbon market has been the low carbon emission reductions originated by the projects, and the high transaction costs of the market. Nevertheless, the possibility of leveraging the EnDev initiatives with carbon finance does not only depend on the quantity of carbon reductions, but also on the price per tonne of carbon. While the current carbon price in the market is approximately EUR 8.5 per tonne, it also has been higher than EUR 20 during 2008 (Point Carbon). It might be possible that the carbon price goes up again, and that carbon finance becomes a good way of partially financing the EnDev initiatives in Mozambique. In order to do this, an accurate carbon baseline emission should be determined.

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Annex I: Details of the EnDev I and II hydropower phases in Mozambique

EnDev I – Hydropower pilot project in Chua

The EnDev intervention in the micro/pico hydropower sector of Mozambique was initiated in 2007 by GIZ through the AMES-M initiative in the western Mozambican province of Manica. The province, bordering Zimbabwe to the West, enjoys sufficient water flows from a range of mountains that stretch from the Ruenha river in the North to the Save river in the South.

A pilot hydropower project in the locality of Chua, within Manica province, was developed in the period 2007-2009 as a first phase of the EnDev intervention. This phase is identified as EnDev I – for the hydropower component in Mozambique.

Figure 3: Map of Sub-Saharian Africa enhancing the location of Manica town

Chua community

Chua is a village located on the mountains that border Zimbabwe. Approximately 260 families live in Chua, and the spoken language is *Shona*, while only half of the population older than 5 years can speak Portuguese. 51 % of the population is illiterate – while more men than women are illiterate, more men than women are able to speak Portuguese due to their greater involvement in economic and social activities.

Figure 4: Map of Mozambique

Shona is a language that integrates some English vocabulary such as numbers. Many Zimbabweans that speak this language have immigrated to Mozambique and their concentration is particularly high at this border village. They share the same culture with Mozambicans from Manica province and are from the same ethnicity, sharing a common history and used to have strong commercial relationships (RWI, 2010).

The EnDev I phase managed by AMES-M consisted in the upgrade of four traditional maize mills in Chua village in Manica district, province of Manica. The maize mills were improved, and four turbines for power generation between 15-18KV of installed capacity were implemented.

EnDev I implementation strategy

For the implementation of the EnDev I pilot project, it was crucial for GIZ to partner with a local organization which had both knowledge of the local context and good acceptance from the inhabitants of the Chua community.

A local NGO based in Manica town was selected: "*Associacáo Kwaedza Simukai Manica"* (AKSM) – a name that means "Wake up Manica, is dawn" –. The NGO was selected mainly due to its knowledge of the rural communities in Manica province, its more than 10 years of experience

working in development initiatives in the region, and because it was already trying to promote the use of renewable sources of energy like micro/pico hydropower generation[19] in Mozambique.

AKSM was contracted by GIZ to be responsible for the implementation of the four hydropower systems in the maize mill facilities selected in Chua. The NGO had a short training period with GIZ technical experts in the field in order to build the required capacities to properly execute the EnDev implementation tasks.

EnDev I in figures

From the approximately 260 families living in Chua, 136 received direct connection to the grid powered by the hydropower systems implemented during the EnDev I phase. Each of the hydropower systems provide electricity within a radius of 1000 meters. Some households located outside this radius got electricity supply via car batteries.

The EnDev I pilot phase finalized its implementation in December 2009, and the figures reported by AKSM in January 2010 on the EnDev I implementation phase were as follow:

Name of Mini-Grid Operator	Direct connect HH		HH on Battery lights		Total Households		Beneficiaries	
	Planned	Actual	Planned HH	Actual HH	Planned	Actual	Planned	Actual
Lino Ndacada	24	35	60	3	84	38	462	209
Jimi Pondo	37	37	40	-	77	37	424	204
Tomas W. Nguarai	40	36	50	1	90	37	495	204
Benjamin E Mucheca	27	28	20	1	47	29	259	160
Areas out of Chua vil.			180	11	180	11	990	61
TOTAL	**128**	**136**	**350**	**16**	**478**	**152**	**2.629**	**836**

Table 10: Beneficiaries figures of Mozambican EnDev I hydropower phase

The EnDev I implementation phase finalized with a total number of 136 households (HH) connected directly to the electricity and 16 HH receiving electricity through car batteries. The 152 HH, when multiplied by the factor of 5.5 people/household utilised by the EnDev programme in Mozambique, resulted in 836 people receiving access to electricity. Additionally, the four hydropower systems implemented in Chua generate energy for social infrastructure in the

[19] AKSM exists officially as an NGO since 2001. Previously it was a programme of the Belgian NGO FSO working in different development issues in Mozambique.

community. The number of beneficiaries from these social infrastructures energised was reported as 920 people by AKSM in January 2010.

An important aspect considered by the EnDev programme for the operation and sustainability of the hydropower systems is the productive use of energy. In January 2010 AKSM reported the following figures for the productive use of energy in the Chua pilot project:

Name of Mini-Grid Operator	Kiosks / shops		N° of people employed	Poultry		N° of people employed	Micro industry		N° of people employed
	Planned	Actual	Actual	Planned	Actual	Actual	Planned	Actual	Actual
Lino Ndacada	5	8	16	2	3	2	2	1	2
Jimi Pondo	2	7	14	2	1	2	1	1	2
Tomas W. Nguarai	2	3	6	2	2	2	1	1	2
Benjamin E Mucheca	2	1	2	2	1	2	1	1	2
TOTAL	**11**	**19**	**38**	**8**	**7**	**8**	**5**	**4**	**8**
Total N° of people employed									**54**

Table 11: Productive use of energy figures of Mozambican EnDev I hydropower phase

EnDev I funding

Also very important in the Chua hydropower pilot project is the strategy on how the initiative was implemented in terms of funding. In this context, each hydropower system could be divided into three components: generation, transmission and distribution. Where,

- Generation means all the investments required to produce the electricity;
- Transmission means all the investments required to bring the electricity to the households. This means then the mini-grid; and

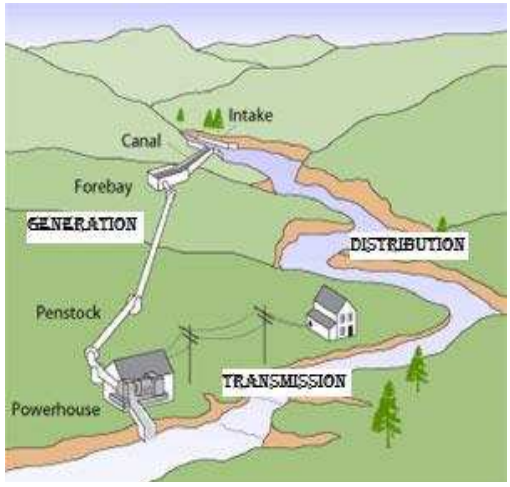


Figure 5: Components of an electrification system

- Distribution means all the investments required to connect each house to the electricity system. This means the household connections.

This is shown in Figure 5.

According to the information provided by AMES-M, the hydropower systems in Chua had an averagecombined cost of EUR 25,000 for the items of generation and transmission. This can be broken down into EUR 9,000 for generation (turbine, generator, etc) and EUR 16,000 for the transmission grid. The costs of distribution – the household connection infrastructure – had a cost of EUR 40 per household approximately.

The manner in which these three items – generation, transmission and distribution – were financed is an important aspect of the EnDev I phase strategy and therefore deserves further explanation.

The implementation of the three items was financed by GIZ/AMES-M through EnDev funds. However, a part of the actual costs was asumed by the beneficiaries and the systems owner/operators, as explained bellow:

The generation investment was covered initially by the EnDev programme in order to make the hydropower system operational. The owners/operators of the systems made a commitment to pay back a 60%[20] of the value of the equipment for the generation and improvements on the maize mill. The payback period agreed on was 24 months. Therefore, the owner/operator was partially subsidized by the EnDev initiative.

In the case of the transmission costs, the mini-grid for each of the four micro hydropower systems in Chua was subsidized in its totality by the EnDev programme.

The costs related to the distribution items, which consisted of equipment and work required to connect each house to the mini-grid, were again covered initially by GIZ/AMES-M with EnDev funds. Again, a commitment was made bt the beneficiaries – the households – to pay back the approximately EUR 40 required to make the household connections, also in a 24-moths period.

Revolving Fund

The back payments of the costs initially covered with EnDev funds – this is the 60% of the generation costs and the household connections costs – were utilized by GIZ/AMES-M and AKSM to establish a Revolving Fund for the Chua community. Therefore, the payments from the owners/operators and each of the households connected to the systems are made to this Revolving Fund. These funds are for communal developments and are administrated by the the inhabitants of Chua village themselves. AKSM only monitors and follows up the re-payments of the debtors to the Revolving Fund.

[20] From the document "AKSM-Chua Micro Hydro Project Progress Report", by AKSM in January 2010

This funding strategy described for the Chua project is schematized next.

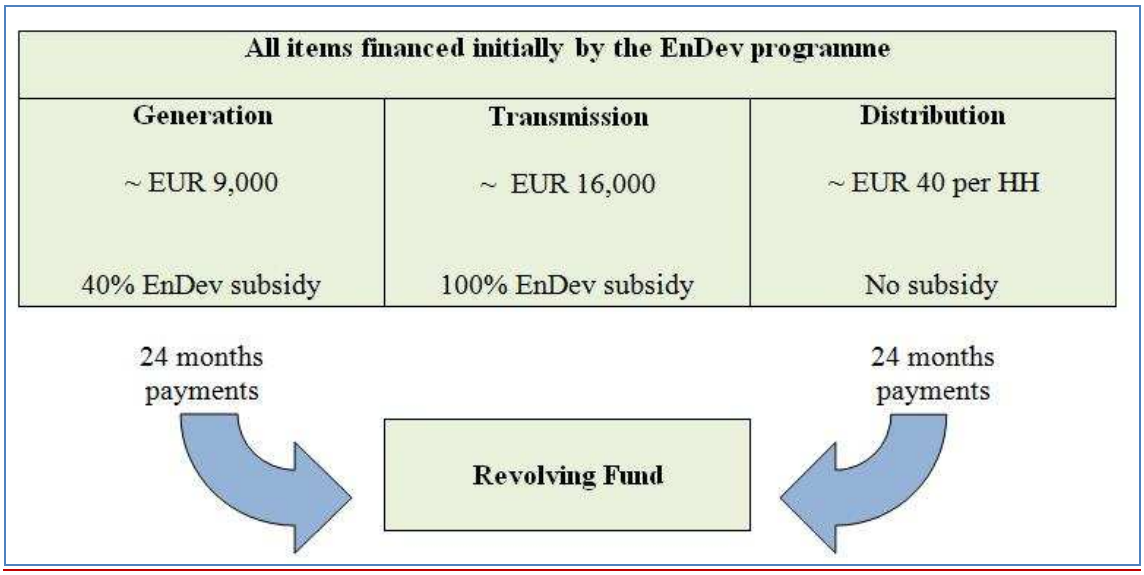


Figure 6: Revolving Fund mechanism in Chua

Operation of the hydropower systems in Chua

The systems generate and supply electricity to the households between 18:00hrs and 6:00 the next day. During the day (6:00-18:00hrs) the systems are used for milling maize.

The consumers pays a flat tariff for the electricity provided by the systems: MZN 200 per month, aproximately EUR 5. The electricity consumption per household is not monitored and therefore it is not possible currently to charge the consumers according the amount of electricty they use.

The owner/operator of the system is in charge of collecting the electricity payments.

EnDev II – 8 Micro and 24 Pico Hydropower systems in Manica Province

After completing the pilot phase in Chua, GIZ/AMES-M designed the EnDev II phase. The new phase targeted to implement 8 new micro and 24 pico hydropower systems during the period 2010-2012 in several districts of Manica province. The systems to be implemented should create benefits for 16,300 rural inhabitants at the end of the phase EnDev II in 2012.

For this second phase, the local NGO AKSM once again plays a crucial role in the design and implementation of the initiatives. They are responsible for selecting the sites of the new systems, suporting the community preparation and participation in the developemnt of the projects, and executing the implementation tasks.

Given the technological feasibility proven with the EnDev hydopower pilot project, this type of power generation solution attracted the attention of the energy national authorities seeking to increase the access to energy in rural areas of the country. In this context, and thanks to the GIZ/AMES-M's negotiation and lobby efforts, the MoE decided to support the work of GIZ/AMES-M and structured a MoU to utilize governmental funds from the FUNAE to leverage the implementation of hydro generation initiatives during the second phase of the EnDev programme.

EnDev II funding

In the context described abouve, and in order to transfer the funds for the EnDev projects, FUNAE signed in 2010 a MoU with the local bank Banco Terra – which at the time of this research was the only local bank that had showed interest in participating in the development of the market for stand-alone energy systems powered with RETs that increase the access to energy in rural areas of the country – . At the same time Banco Terra sigend a MoU with GIZ/AMES-M to finance hydropower generation schemes under the EnDev programme.

Under this new funding strategy, the bank finances partially the investment for the generation item only, meanwhile the transmission and distribution items are funded in the same way of the EnDev I phase described previously. In this way, the owners/operators of the EnDev II systems receive a loan from the bank, which should be payed back in a certain period of time agreed for each particular contract. The part of the power generation investment that is not financed by the bank is subsidied by the EnDev programme.

This new funding strategy recently developed by GIZ/AMES-M has basically two main goals: on the one hand aims to involve local financing institutuions – and also others types of institutions – in the development of the RETs sector; and on the other hand it aims to reduce the EnDev subsidy for the new hydropower generation schemes that shall be implemented during the second phase.

EnDev II at the time of this research

The above described EnDev II phase was in full implementation stage at the time of the field work for this research in Mozambique and hence no hydropower systems of the EnDev II phase were yet operating, and even more, no funds from FUNAE were yet released or even committed through Banco Terra for the implementation of EnDev project activities.

Annex II: Adaptation of the SAF-EnDev tool

Adaptation of the SAF-EnDev tool

The "Sustainability Assessment Framework for EnDev project activities" presented in Annexe II is a generic frame aiming to address the sustainability issue of a diverse type of projects being implemented in more than twenty different developing countries in Africa, Asia and Latin America under the EnDev programme.

Even though all the EnDev projects implemented globally have the main original goal of increasing the access to energy, they vary in technology utilized, product/service being disseminated, implementation and diffusion strategy, enterprise design and business model, and naturally in the characteristics of the host country and local market. Hence the SAF-EnDev tool is merely a guideline on how a sustainability assessment should be addressed for EnDev initiatives. In consequence, the tool requires tailor made adjustments according to the nature and characteristics of the EnDev intervention that is assessed.

In the case of the EnDev hydropower component assessed in Mozambique the benefit being provided to consumers is the access to electricity, benefit that for the purpose of this research is understood as a service.

Thus, this annex details the adapted sustainability assessment framework utilized to analyze the EnDev hydropower module in Mozambique. For each of the four key dimensions addressed by the tool slight changes to the sub-dimensions and qualitative assessment questions suggested were made in order to adjust the framework to the nature and characteristics of the EnDev initiative assessed. The main adjustments were made in the dimension related to the *Consumer behaviour* since the first original version of the tool is pretty products oriented, and as it has been explained above, the EnDev consumers in Mozambique receive electricity supply, which is understood as a service.

Consequently, the final adjusted version of the SAF-EnDev tool utilized to analyze the four key pillars of sustainability of the EnDev hydropower component – with the respective sub-dimensions and qualitative assessment questions – is as follow:

Enabling environment adapted (EEA)

No major adjustments were required for this dimension of the SAF-EnDev tool. The only modification done was the elimination of sub-dimension touching the issue "*Supplier-buyer density network*" (EE3.1 in the original version of the SAF-EnDev), since it was not in line with the characteristics of the EnDev projects being assessed and the local market.

The *Enabling environment adapted* version utilized is as follow:

EEA1	Policies and regulations
EEA1.1	Presence of supportive policies and regulations to enable the diffusion of RETs
EEA1.2	Presence of national and regional programs supporting the diffusion of RETs
EEA1.3	Presence of clear motivating factors for use of RETs

EE1.1: Presence of supportive policies and regulations to enable the diffusion of RETs

1. Are there government polices currently in place that support the diffusion of renewable energy technologies?

EE1.2: Presence of national and regional programs supporting the diffusion of RETs

1. Are there local/regional government programs for the training and development of RET technicians and entrepreneurs?
2. Are there national or regional programs for the development of RET markets?
3. Is renewable energy incorporated into development and poverty reduction strategies?

EE1.3: Presence of clear motivating factors for use of RETs

1. Is there a target set by the government in relation to the use of renewable energy in the future?
2. Are there complimentary policies, such as environmental regulations in favour of RETs?

EEA2	Local agencies and their role
EEA2.1	Capacity of local market institutions and supportive actors
EEA2.2	Availability of technology diffusion support systems

EEA2.1: Capacity of local market institutions and supportive actors

1. Do RET agencies (local/regional) have sufficient capacity and resources to support the use of renewable energy?
2. Are energy policy and RET issues available in technical and vocational school curricula?
3. Is the promotion of RETs supported at all levels of government?
4. Are local needs, in relation to the technology in focus, timely articulated by the relevant bodies?

EEA2.2: Availability of technology diffusion support systems

1. To what extent are technology extension services being provided?

2. Are there maintenance technicians (private entrepreneurs or also public employees) at the local level providing adequate services?

3. Are there graduates (technicians) from vocational and technical training institutions related to renewable energy technologies?

4. Are there micro-credit institutions readily accessible to potential energy technology users?

5. Are there cost sharing schemes currently in place to support the use of RETs?

EEA3	**Partnerships among local agencies and other actors**
EEA3.1	Presence of civic societies, associations and advocacy groups

EEA3.1: Presence of civic societies and associations

1. Are there strong partnerships among various stakeholders with a shared commitment in the promotion of renewable energy technologies?

2. Are there associations of enterprisers and technology users?

3. Are there advocacy groups providing legitimacy to the technology at various levels?

Consumer behaviour adapted (CBA)

This dimension required important adaptations since the original version of the tool is quite oriented to products. Thus, several modifications were required in order to adjust the SAF-EnDev guideline to the nature of the projects being assessed, the benefit being provided and the local characteristics.

The beneficiaries of the hydropower systems assessed are provided with connections to a mini-grid system that supplies electricity. Thus, the benefit being provided is understood as a service for the purpose of this research. Therefore it was necessary to adapt the *Consumer behaviour* dimension to the context of a service.

The *Consumer behaviour adapted* version utilized is as follow:

CBA1	The household capacity
CBA1.1	Knowledge and skills levels of consumers regarding the use of electricity
CBA1.2	The hydropower systems implemented are in line with the household economy
CBA1.3	The household financial capacity corresponds to the cost of electricity
CBA1.4	The household owns the physical capital needed

CBA1.1: Knowledge and skills levels of consumers regarding the use of electricity

1. Does the target group posses the skills needed to correctly use the electricity?
2. Does the program provide skills training to consumers?

CBA1.2: The hydropower systems implemented are in line with the household labour economy

1. Do consumers experience a gain in labour time through the technology adoption?

CBA1.3: The household financial capacity corresponds to the cost of electricity

1. What is the willingness to pay?
2. How does the cost of electricity relate to income levels?
3. Do households generate extra income thanks to the electricity access?

CBA1.4: The household owns the physical capital needed

1. Is the electricity provided compatible with the living conditions of the majority of consumers?
2. To what extend is the technology compatible with the household existing resource endowment?

CBA2	The social environment
CBA2.1	The technology is in line with existing norms, values and cultural preferences
CBA2.2	The technology is accepted by the society

CBA2.1: The technology is in line with existing norms, values and cultural preferences

1. Does the technology comply with cultural practices and preferences?
2. Does the technology demand a change in existing habits from the household and if so how does it impact their traditions?

CBA2.2: The technology is accepted by the society

1. Do households gain prestige within the community when having access to electricity (creation of socio-economic status)?
2. How does the community value the technology?

CBA3	User awareness of benefits
CBA3.1	Consumer awareness of the technological advantages
CBA3.2	Consumers are satisfied with the product

CBA3.1: Consumer awareness of the benefits of having electricity access

1. Are households aware of the advantages of having access to electricity?

CBA3.2: Consumers are satisfied with the electricity service being provided

1. Have the consumers experienced problems with the electricity supply?
2. How often do the consumers experience problems with the electricity supply?

CBA4	Access to consumer good markets and services
CBA4.1	Appliances for the use of electricity are accessible by the household
CBA4.2	Access to maintenance services
CBA4.3	Accessibility of the technology

CBA4.1: Appliances for the use of electricity are accessible by the household

1. How much does a household need to spend on acquiring appliances?
2. Do local markets offer appliances?
3. What is the distance to the nearest market?
4. How reliable is the appliance market?

CBA4.2: Access to maintenance services

1. Can consumers easily access maintenance support in case of a technical problem?

CBA4.3: Accessibility of the technology

1. Are there alternative technologies/fuels available and what is the relative price difference?

Enterprise design and business planning Adapted (EDA)

This dimension also required some adaptations since the hydropower plants implemented in Chua – and the plants that will be implemented in others districts of Manica province during the phase EnDev II – are owned by rural inhabitants without technical knowledge on business development, administration, project planning, marketing, finance, etc. The business design for the EnDev hydroelectric systems implemented during EnDev I was done by GIZ/AMES-M and AKSM, and the same was happening for the EnDev II phase at the time of the field work in Mozambique. Thus, several sub-dimensions and qualitative assessment questions were adjusted and addressed in the

view that GIZ/AMES-M and AKSM are the promoters of the EnDev power generation business initiatives.

An important adjustment to the original version of the tool was the omission of some sub-dimensions. The section addressing the marketing activities (ED2.3) of the EnDev initiatives was omitted since these ones were nonexistent for the hydro projects implemented in Manica. Also the section touching the issue of human resources of the enterprise (ED4) was omitted, since as it was mentioned above, the systems are owned by rural inhabitants that operate the hydro plants themselves jointly with their families; hence it was not possible to address the human resources issue in the way that the SAF-EnDev tool suggests. The section addressing the issue of distribution networks and retailers (ED5.2) was also omitted in the assessment since it did not apply to the nature of the EnDev projects assessed (the hydropower plants analyzed do not have products to be distribute with retailers).

The *Enterprise design and business planning adapted* version utilized is as follow:

EDA1	**Market information**
EDA1.1	Consumer information is used for business planning
EDA1.2	Product usability information is collected through field testing
EDA1.3	Entrepreneurs are aware of energy access policies and regulations

EDA1.1: Consumer information is used for business planning

1. Have market studies including comprehensive consumer data been performed by the enterprise or other organizations?
2. Does the enterprise have an ongoing mechanism for collecting, monitoring, and responding to consumer and product data?
3. Have the project promoters used consumer data to improve business planning?

EDA1.2: Technology usability information is collected through field testing

1. Has the project promoters conducted a pilot activity for field testing?

2. Has the project promoters adjusted the projects design/strategy based on greater knowledge of projects performance?

3. Is feedback collected on the technology performance?

EDA1.3: Level of regulatory knowledge held by project promoters is increased

1. Do the promoters have developed a network with regulatory officials and advisers?

2. Are the planned activities of the EnDev promoters aligned with national energy policy and planning goals?

EDA2	Sales, Marketing, and Costumer Services activities
EDA2.1	Sales, marketing, and costumers service activities leverage trust and social networks
EDA2.2	Payment and finance mechanisms established are supportive of s sustained system operation
EDA2.3	Marketing activities raise consumer awareness effectively

EDA2.1: Sales, marketing, and costumers service activities leverage trust and social networks

1. Do the owners/operators and/or the EnDev promoters perform sales, marketing and customer service activities?

EDA2.2: Payment and finance mechanisms established are supportive of sustained system operation

1. Does the owner/operator employ flexible consumer payment mechanisms (such as pre-paid cards or fee-for-service payments)?

2. Have the EnDev promoters partnered with local financial institutions to develop lending products for energy services?

EDA3	Financial management
EDA3.1	The enterprise is able to recover start-up and operational costs
ED3.1	Scalability of the enterprise is financially feasible
ED3.2	The design and implementation of subsidies used is supportive of business growth

EDA3.1 The EnDev projects are able to recover start-up and operational costs

1. Have the EnDev promoters performed a financial analysis including IRR, ROI, payback period, and breakeven analyses?

2. Do the prices set allow for full cost recovery?

EDA3.2 Scalability of the EnDev hydropower business is financially feasible

1. Do the EnDev hydropower systems have a business plan?

2. Are potential investors positive in considering further investment for expansion?

3. Have the EnDev promoters considered business risks and risk mitigation for systems expansion?

4. Have the EnDev promoters considered engaging the initiatives in carbon finance?

EDA3.3 The design and implementation of subsidies used is supportive of market development

1. Does the subsidy effectively increase access for the very poor?

2. If a direct subsidy has been used, is there a viable exit strategy?

3. Does the subsidy affect consumer willingness to pay?

4. Does the subsidy fund trainings and education for entrepreneurs?

EDA4	**Operations of the hydropower systems**
EDA4.1	Extent of monitoring and quality control

ED4.1 Extent of monitoring and quality control

1. Is electricity use and consumer satisfaction monitored?
2. Are the owners/operators trained in monitoring activities?
3. Are the hydropower plants certified by a quality agency?
4. Have innovations been developed as a result of monitoring activities?

Environmental sustainability Adapted (ESA)

This dimension did not required major adjustments since it is pretty straightforward it the SAF-EnDev original version. It basically aims to address the issue of potential environmental impacts of the EnDev initiates. The nature of the hydropower plants implemented in Manica province is quite environmentally friendly since the systems take the water from its natural course upstream of the powerhouse and return it to the natural flow some meters downstream it. Consequently, the power generation in this case do not consider more inputs materials than the water.

Thus, the *Environmental sustainability adapted* version utilized is as follow:

ESA1	**Environmental sustainability of the EnDev hydropower systems operating**
ESA1.1	Environmental impacts of systems' operation

ESA1.1 Environmental impacts of systems' operation

1. Is there a clear environmental regulatory framework for the type of EnDev project being assessed?
2. Has an Environmental Impact Assessment (EIA) been performed for the EnDev hydropower systems operating?

Annex III: FGD Guideline

Focus Group Discussion facilitator guideline

INTRODUCTION

- This research is about the sustainability of the micro-hydro systems operating in the communities.
- The discussion will last for about 2 hours. At the end of the discussion we will offer some refreshments.
- All your opinions in favour or against the hydro system bringing electricity to your community are welcome. Please feel free to express all your thoughts.
-

BASIC INFO

1. – Do you have electricity connection at home?
2. – When have you been connected to the electricity?
3. – What process did you have to follow in order to get electricity connection?

AWARNESS

4. – Do you think it is important/useful to have access to electricity? Explain/Discuss
5. – Do you prefer de current situation with access to electricity or the previous situation without electricity available in your community? Explain/Discuss

SOCIAL ACCEPTANCE

6. – Do you think that the hydroelectric system generating electricity brings benefits to your community? Explain/Discuss
7. – Do you believe that the households connected to the electricity gain prestige with the community?

SOCIAL ENVIRONMENT

8. – Have your daily habits changed since you got electricity connection at home?
9. – What daily habits have you changed since you got electricity connection?
10. – How do you feel about these changes?

BENEFITS

11. – Is the access to electricity bringing benefits to you? Explain/Discuss
12. – is the access to electricity bringing benefits in your household? Explain/Discuss

HOUSEHOLDS ECONOMICS

13. – Do you experience a gain in labour time now that you have access to electricity?
14. – What is the source of income in your household?

15. – How does the cost of income relates to the income level of your household?
16. – Does your household generate extra income since you have access to electricity?
17. – For what do you use the electricity at home? (Name appliances)
18. – Have you bought appliances since you got access to electricity? Which ones?
19. – How much money did you need or you will need to buy those appliances?

MARKET

20. – Is it possible for you to access credit with formal institutions to purchase appliances?
21. – Can you find these appliances in the local market?
22. – what is the distance to the nearest market?
23. – Is there a place where you can bring your appliances and get maintenance or repair them?

SATISFACTION

24. – Have experienced problems with the electricity connection?
25. – How often have you experienced these problems?
26. – Is there something that you do not like about the system that is bringing electricity to you and your community?

Annex IV: People interviewed

The author interviewed the following people:

Arquimedes Mahanjane – Branch Manager, Banco Terra, Chimoio.
Domingo Neto – Executive Director, AKSM, Manica.
Jemusse David – Natural Resources Manager, AKSM, Manica.
Jose F. Coelho, General Director, Metalurgica, Manica.
Olavo Deniasse, Director, DIPREME, Manica.
Dr. Masinga, Director, ISPM, Chimoio.
Alvaro Zacarias, Director Department Natural Sciences and Mathematics, UP, Chimoio.
Francisco Sacama, Director, UCM, Chimoio.
Manuel Jardim, Director, Eao, Chimoio.
Mario E. Nunes Basana, Manager Unit of Mini-hydro, Biomass and Generators, FUNAE, Maputo.
Charles Tamal Chidamba, Technical Engineer, GIZ/AMES-M, Chimoio.

Annex V: Details of the findings for each main pillar of the SAF-EnDev tool

This Annex presents in detail the information gathered during the field work in Mozambique, which is presented summarised in Section 4 of the report. For each sub-dimension belonging to one of the four main dimensions of the SAF-EnDev tool, the corresponding indicators are assessed in detail.

I. *Details on the sustainability of the EnDev hydropower systems according to the local enabling environment*

As it was mentioned in section 4, the *Enabling environment* for the promotion of micro/pico hydropower systems in Mozambique was addressed focusing on:

- *Policies and regulations*;
- *Local agencies and their role*; and
- *Partnerships among local agencies and other actors*

These issues were addressed through interviews with different entities holding a stake in the field of renewable energy, specifically in micro/pico hydro generation. The details of findings are as follows:

EEA1 - Policies and regulations

This issue was addressed during the interviews with AKSM, GIZ/AMES-M, DIPREME and FUNAE. The findings are as follows:

EEA1.1 - Presence of supportive policies and regulations to enable the diffusion of RETs

The Mozambican government has in recent years started developing a policy framework to promote the development of new and renewable energies. The local Ministry of Energy (MoE) has a document from 2009 entitled "Policy about Renewable Energies in Mozambique" and a unit within the MoE is in theory devoted to the diffusion of renewable energies, the "Direção Nacional de Energias Nova e Renovaveis", DNER.

Even when these favourable policies for the dissemination of RETs exist, these are pretty new and they only pretend to lay the foundations for future developments of the sector. In the specific case of micro and pico hydropower, the mentioned policy document only suggests as a strategy to assess its potential in the country.

Thus, the presence of supportive policies and regulations that enable the diffusion of RETs in the country – and particularly micro/pico hydropower – has a medium contribution to sustainability since the existing policies are pretty incipient and only suggest the assessment of the potentialities but do not set strong directives for the promotion and diffusion of RETs.

EEA1.2 - Presence of national and regional programmes supporting the diffusion of RETs

The mentioned policy document laying the foundations for new and renewable energies is a national framework and no formal local/regional governmental programmes exist for the diffusion of RETs. Only recently, in the last 18 months, the provincial energy authority in Manica province, DIPREME, has initiated cooperative efforts jointly with GIZ/AMES-M and FUNAE to promote the diffusion of micro/pico hydropower initiatives in the districts of Manica province. Those efforts have been mainly on training about micro/pico hydropower.

At the same time, others several international donors give support to the MoE and FUNAE on its mission of increasing the access to energy by implementing renewable energy programmes: the World Bank, the Dutch-German EnDev programme and others. Nevertheless these different programmes are implemented quite independently by each donor without significant cooperation and coordination efforts for implementation. This fact requires the energy Mozambican authorities to maximise its efforts in order to cope with the requirements of each international donor.

On the other hand, a positive signal for the diffusion of RETs is that these are considered when designing the strategies for poverty reduction, being the authority aware of the potential that RETs have to support the efforts of poverty alleviation. In this context, the poverty reduction is one of the main objectives of the document "Policy about Renewable Energies in Mozambique". At the same time, at provincial level, DIPREME makes its annual pacification in coordination with the provincial authority looking after the poverty issue, the "Direção Provincial de Planes y Finanzas", DPPF. It was also gathered that, in theory, DIPREME is working on the development of a RETs diffusion strategy at provincial level for Manica province, but no official outputs from that work existed at the time of this research.

Consequently, given the arguments above, the score regarding the presence of national and regional programmes and its contribution to the sustainability of the projects is medium.

EEA1.3 - Presence of clear motivating factors for use of RETs

Additionally, the incipient policy framework for the development of RETs described does not set targets regarding the use of renewable energy in the future; and neither is it complementary with environmental regulations that favour the diffusion of RETs. This last fact could be explained as a way of not limiting the development of the energy sector. The access to energy in the country is extremely low and limiting the development of certain types of power generation (i.e.: thermo power plants) through renewable energy targets or environmental regulations might be counterproductive for the increment of energy access, according to what was expressed by FUNAE's responsible.

Thus, there is not a presence of clear motivating factors for the use of RETs, and hence the score here is the minimum: no contribution to sustainability.

EEA2 - Local agencies and their role

This issue was addressed during the interviews with AKSM, GIZ/AMES-M, DIPREME, FUNAE, Banco Terra, Metalurgica, UP, ISPM, UCM and EAO. The findings are as follows:

EEA2.1 - Capacity of local market institutions and supportive actors

The promotion of micro/pico hydropower initiatives is a new issue in the country and major previous experiences do not exist. Thus, local governmental agencies are only recently being trained in the field; the same happens with private entities. The premature state of development of the sector is translated in the lack of sufficient capacity and resources that may currently support its development on a larger scale. The best example that describes this situation are the difficulties that GIZ/AMES-M has faced to find local partners with whom to join forces to promote the development of the micro/pico hydropower sector in Manica province. GIZ/AMES-M has basically been the main entity pushing for development of this type of initiative and building the capacities for the development of the sector. Governmental staff along with the staff of the local NGO ASKM have only recently been trained in the micro/pico hydropower field with EnDev resources in order to start building the required capacities.

Image 1: Turbines production line at Metalurgica's facilities

A positive but very incipient fact that is interesting to mention in regard the development of markets institutions is the presence in Chimoio (capital of Manica province) of a company manufacturing the turbines for the EnDev hydropower systems: Metalurgica. The firm had recently started developing a production line to make turbines at the time of this research. During the interview, Metalurgica's managers expressed that the company is keen to get more involved in the development of the hydropower sector in the country and it was designing a new business line in order to offer in-situ implementation and maintenance services for the turbine equipments that the firm produces. This is a very positive sign for the RETs' local market expansion; nevertheless it is still at a very early stage and needs further development.

On the other hand, there are not courses related to energy policy and RET issues available in the educational institutions of Manica province. All the educational entities interviewed in the province confirmed this situation; however they expressed their interest in joining efforts with GIZ/AMES-M in order to place these issues into their curricula.

The situation described in regard the current transverse lack of local capacities and resources in the micro/pico hydropower sector is translated in the slow responses to local needs in relation to the technology. A good example of this fact is the legal status of the EnDev hydropower systems implemented in Mozambique: the existing power generation regulation in the country does not consider the generation from micro/pico off-grid systems and hence the hydropower initiatives implemented by GIZ/AMES-M under the EnDev programme were not being recognized by the provincial commerce authorities at the moment of the field work for this research. This fact puts at risk the sustainability of the hydropower plants since these are not being taxed accordingly and therefore the owner/operators might face taxation penalties in the future. This situation regarding the legal status of the EnDev hydropower systems has been exposed to the authorities according to what AKSM expressed, and also modifications to the existing power generation regulations have been requested. Nevertheless the authority has not articulated a formal solution for the described situation, showing a slow response to the needs of the sector and a weak support for the promotion of RETs at all levels of government.

Therefore, given the situations above described, the capacity of local market institutions and supportive actors receive a low score.

EEA2.2 - Availability of technology diffusion support systems

As it has been mentioned previously, the micro/pico hydropower sector is recently being developed in Mozambique, existing low human capital involved in the sector. This translates into the scarce availability of experienced technicians in Manica province were the EnDev hydropower projects are located and therefore few maintenance and extension services are being provided by technicians to the existing EnDev hydro generation systems.
The Chua hydropower projects currently operating receive maintenance directly from the owners/operators since they had a 2-3 days training period on the matter during the implementation phase of the generation plants. When more complex operative issues affect the systems, AKSM is responsible for assisting the owners/operators to solve the problems. Thus, the NGO and GIZ/AMES-M are basically the only organisations where the owners/operators in Chua ask for technical expertise currently.

On the other hand, regarding the availability of financing support systems for the diffusion of this type of hydropower initiatives the findings are positive: thanks to the initiative and efforts of GIZ/AMES-M the local government put in place in 2010 a memorandum of understanding (MoU) with GIZ/AMES-M and the local bank Banco Terra for the financing of micro/pico hydropower schemes utilising governmental funds of FUNAE. Banco Terra should act as financing canal to support the implementation of micro/pico hydropower projects. Therefore, Mozambique counts on local institutions and financing sharing schemes ready to support the implementation and use of micro/pico hydropower initiatives.

In consequence, given the scarce availability of technicians and extension services, but at the same time the existence of local institutions available to finance micro/pico hydroelectric schemes, the availability of technology diffusion support systems score is medium.

EEA3 - Partnerships among local agencies and other actors

This issue was addressed during the interviews with AKSM, GIZ/AMES-M and DIPREME. The findings are as follows:

EEA3.1 - Presence of civic societies and associations

Currently in Mozambique there are no formal associations or groups of stakeholders working co-ordinately in the promotion of RETs in general. Promoters of different off-grid technologies aiming to increase access to electricity in the country usually work independently and in specific occasions partnering other organizations with similar interests in promoting a certain technology/project. Several NGOs, international cooperation agencies, and also governmental entities work in the promotion of RETs and off-grid solutions in the country; nevertheless there is not a formal agreement or alliance between all the promoters and stakeholders to work jointly in the diffusion of RETs. This situation described also applies for the micro/pico hydropower sector: there are not national or regional associations promoting the use and legitimacy of these types of hydropower technologies.

On the other hand, a periodic steering committee organised at ministerial level exists formally three times a year for the entities working in the increase of energy access in the country. The idea of the committee is to share and solve common problems in cooperation; nevertheless this does not happen often according to AKSM and GIZ/AMES-M view, and such instances are used basically by the different entities involved in the RETs sector to show their own initiatives being implemented.

Consequently, strong national partnerships among various stakeholders with a shared commitment in the promotion of renewable energy technologies do not exist in the country, which is also the case with advocacy groups legitimising the micro/pico hydropower technologies. Perhaps the most positive aspect in the context of local partnerships is the existence of an owners/operators committee in the Chua community. Such a committee aims to share experiences and address jointly the developments on energy access within the community; nevertheless it is far from being strong.

Accordingly, there is no presence of strong civic societies and associations supporting the promotion of RETs and micro/pico hydropower in particular. Thus the score here is low.

Thus, given the information gathered during the field work and presented here, the *Enabling environment* dimension received a final overall score of 0.32, which according to the scoring systems proposed by the SAF-EnDev tool means a contribution to sustainability between low and medium.

II. Details on the sustainability of the EnDev hydropower systems according to the consumer behaviour

The *Consumer behaviour* dimension was assessed through FGDs for the EnDev micro/pico hydropower systems operating in Manica province as it was described in Section 3. The assessment focused the four main aspects that describe the attitude of the consumers towards the electricity service being provided and hence help to form an idea of acceptance and value given by the beneficiaries to the projects. The sub-dimensions addressed are:

- *The household capacity*;
- *The social environment*;
- *User awareness of benefits*
- *Access to consumer goods markets and services*

The findings are as follows:

CBA1 – The household capacity

CBA1.1 - Knowledge and skills levels of consumers regarding the use of electricity

The benefit being provided by the EnDev hydropower systems (the electricity supply) does not require big skills from the consumers initially. During the FGDs it was possible to realise that the beneficiaries of the Chua projects are aware of all the basic/normal uses of electricity (lighting, TV, radio, cooling, charging cell phones, etc) and also some potential productive uses (welding, poultry breeding, barber shop, etc). Nevertheless there are more potential productive uses of electricity that could be implemented (i.e.: bike shop, sewing, etc.) if the inhabitants of Chua get the skills to do so. On the other hand, the consumers of the Chua hydropower plants have not got any type of training on the potentialities of the productive uses of energy.
Consequently, the knowledge and skills of the consumers regarding the use of electricity receive a medium score. This is mainly because there are more potential uses of energy that could be implemented, and for that the people will require training.

CBA1.2 - The hydropower systems implemented are in line with the labour household economy

According to the responses during the FGDs the beneficiaries experience a gain in time thanks to the projects since they do not need to go in town buying other lighting alternatives (candles and kerosene mainly). Also, they can now keep their food in fridges, thus they reduce the frequency of buying food and therefore experience a gain in time. Nonetheless, time is not precisely the scarcest resource for Chua inhabitants. Hence the gain in time has only a medium contribution to the household labour economy and the project's sustainability.

CBA1.3 - The household financial capacity corresponds to the cost of electricity

The consumers of the projects in Chua pay a flat tariff monthly for the electricity supply. The monthly fee is MZN 200 (miticais, the local currency in Mozambique; fee equivalent to EUR 5 approximately); an amount that is independent of the energy consumption per client. During the

FGDs, when asked about their willingness to pay this fee, the generalized answer from the consumers was that the amount is very good for them. Nevertheless when asked about the relation between this amount and their household monthly income the responses reflected that this amount is between 40-70% of the money available at home monthly. This information is quite interesting since it shows a rather low availability of monetary resources in the households; however the interesting issue here is that the inhabitants of Chua community practice mainly a rural subsistence economy, and now with the electricity provided by the EnDev hydropower plants they have acquired a monetary responsibility that previously was non-existent. Anyhow, to talk about household financial capacities with beneficiaries of development projects is always tricky and hence this information should be taken with a grain of salt.

On the other hand, the electricity access has originated some new business opportunities for the beneficiaries in Chua village. Some new shops selling groceries and cold drinks have been initiated as well as barber shops and poultry breeding businesses, nevertheless there is still more potential for productive uses of energy that could be implemented. Also some families occasionally buy bigger quantities of fish and meat in Manica town and keep them in the fridges in order to sell them later, creating an extra income for the household.

Image 2: FGD with consumers of Tomas Guarai's system

Thus, according to the information gathered during the FGDs it is possible to say that the electricity fee being charged by the EnDev hydropower plants is in line with the household financial capacity and hence this indicator receives a high score.

CBA1.4 - The household owns the physical capital needed

The provision of electricity does not require special conditions in the households and hence the current living circumstances of these ones are perfectly suitable for the basic uses of power (lighting, TV, etc.). On the other hand, it was gathered during the FGDs that the households connected to the mini-grid powered by the EnDev hydropower plants spend usually between MZN 10,000-20,000 (EUR 250-500) buying the normal basic appliances (TV, radio, DVD, fridge, bulbs). Logically, these appliances were nonexistent in most of the households previous to the electricity connection (only a few households in Chua village had solar PV panels and micro thermo generators implemented previous to the EnDev hydropower systems, and hence counted on some of these appliances). Therefore the connection to electricity entails an important investment from the families; investment that according to the FGDs has been done already partially by the families.

Consequently, even when the living conditions of the families in Chua are compatible with the electricity services being provided, the required high investments to acquire appliances puts

pressure on the reduced budgets of the households and hence affects the sustainability of the projects. Thus, the score for this indicator is medium.

CBA2 – The social environment

CBA2.1 - The technology is in line with existing norms, values and cultural preferences

It was possible to gather during the FGDs that the connection to electricity has brought several changes in the normal habits of Chua village inhabitants. Since they got power in their households the families spend more time at home watching TV, listening radio, or just spending time with the rest of the family at night with the households illuminated. Previously they used to spend several hours during the day outside their homes chatting with neighbours, but now this is less common given the new entertainments that the electricity provides them at home: TV, DVD movies, reading at night, radio, etc. This situation occurs with children and adults. Also, Chua's inhabitants are now able to play the radio outdoors and organize parties during the weekends, a fact that is much appreciated.

On the other hand, some of their eating habits have changed as well since now the families are able to keep the food and drinks in fridges; hence some perishable foods are kept now for longer and rationed, meaning that they can eat it more times a week than previously. The cold drinks are also much appreciated and a new source of income sometimes for the households.

When consulted about how they feel about these habits changing, the general answer from the consumers was that they like the changes and they prefer the current situation over the previous one. Thus the technology scores high in regard to its compliance with the cultural preferences, norms and values.

CBA2.2 - The technology is accepted by the society

According to the discussions during the focus groups, the households connected to the electricity gain prestige within Chua community. At the same time, the FGDs confirmed that the EnDev hydropower systems are highly valued by Chua's inhabitants. People agree that the systems bring tremendous benefits to the community.

In this context, an interesting issue came up during the FGDs: the people really appreciate the Revolving Fund existent in Chua[21], instituted along with the implementation of EnDev hydropower plants and designed as a seed capital for the community by GIZ/AMES and AKSM. People associate the existence of the Revolving Fund with the hydropower projects and hence give a high value to the EnDev systems.

Thus, the hydroelectric projects receive a high score in regard the value and acceptance of the society.

[21] For more details on the Revolving Fund in Chua please refer to Annex I.

CBA3 - User awareness of benefits

CBA3.1 - Consumer awareness of the benefits of having electricity access

As it was mentioned previously, the inhabitants of Chua village give a high value to the fact of having access to electricity. The main benefits they perceive are related to lighting their households and public areas on one hand, and the use of common basic appliances (TV, radio, fridge, etc) on the other hand. They also have plans to bring the electricity to some communal facilities like the school and small clinic existing in the village, mainly for lighting. Nevertheless, as it was mentioned earlier, the people is not fully aware of all the potentialities – and hence benefits – that the productive use of energy might bring them. Thus, the user awareness of the electricity benefits scores medium.

CBA3.2 - Consumers are satisfied with the electricity service being provided

Image 3: FGD with consumers of Lino Ndacada's system

When asked about their satisfaction in regard the projects performance, the consumers expressed in general a good level of satisfaction; nevertheless they remarked that some problems exist with the electric current being supplied since sometimes the voltage is too low and it is not even possible to watch TV. Some inhabitants mentioned as well that certain types of appliances like welding and sewing machines do not work with the current being provided. The low voltage problem is currently constant according to the information gathered and it might be due to a low flow of water entering the hydropower system, this is later discussed in Section 6. Additional to these findings on problems with the current; it was also possible to realise that the people want to have electricity 24hrs a day – currently the systems provide electricity from 18:00hrs to 6.00hrs the next day[22]–. In this context, some consumers expressed also that the fact of having power only at nights originates deterioration in appliances like fridges; the re-start of the cooling engines every evening seems to deteriorate the performance of these appliances and therefore to reduce its life span.
Thus the consumers' satisfaction regarding the electricity services being provided receives a score of medium.

[22] For more details on the operation of the EnDev hydropower systems in Chua please refer to Annex I.

CBA4 - Access to consumer goods markets and services

CBA4.1 - Appliances for the use of the electricity are accessible by the household

As it was mentioned earlier, the cost of the common/basic appliances for the households (TV, radio, DVD, fridge, etc.) is between MZN 10,000-20,000 (EUR 250-500). These appliances are all available in the markets of Manica town, approximately 16 kilometres away from Chua village. The mentioned markets have products from different origin, qualities and prices. Thus, the accessibility of appliances for the consumers scores high.

CBA4.2 - Access to maintenance services

In case of maintenance or problems with the appliances, the inhabitants of Chua village can find technical services in Manica town and also in Chimoio city. Therefore the access to maintenance services receives a high score.

CBA4.3 - Accessibility of the technology

According to the information gathered during the FGDs, some wealthy families in Chua had electricity in their households previous to the implementation of the EnDev hydropower systems. This it was through solar PV technologies and diesel generators. This means that Chua inhabitants do have alternative technologies to get electricity. Nevertheless, the reason why the majority of the households did not have such power generation technologies – and therefore did not have electricity – was due to the high costs. Then, the high number of households connected to the mini-grid powered by the EnDev hydropower plants means that the MZN 200 fee that is being paid by the consumers is notoriously lower than the alternative technologies for power generation. Thus, the accessibility to the technology contributes highly to the sustainability of the hydroelectric projects and hence receives a high score.

Consequently, given the information gathered during the FGDs and presented in detail here, the *Consumer behaviour* dimension received a final overall score of 0.78, which according to the scoring systems proposed by the SAF-EnDev tool means a contribution to sustainability between medium and high.

III. Details on the sustainability of the EnDev hydropower systems according to the enterprise design and business planning

The *Enterprise design and business planning* of the EnDev hydropower systems being implemented in Manica province was assessed through interviews with entities involved in its implementation, and also with project owners/operators. In line with the SAF-EnDev guideline, the issues considered for the analysis of this pillar were:

- *Market information;*
- *Sales, marketing and customer service activities;*
- *Financial management;* and
- *Operation of the projects*

These sub-dimensions have a slightly different approach to the original version of the SAF-EnDev tool. For more details on the adaptation of the tool please refer to Annex II. The findings are as follow:

EDA1 - Market information

This issue was addressed during the interviews with GIZ/AMES-M and AKSM.

EDA1.1 - Consumer information is used for business planning

From the discussions with GIZ/AMES-M and AKSM it was possible to gather that a baseline study on energy use and socio-economic conditions in Chua community was done in 2008 by GTZ and the German organization RWI[23]; such a study was used to design the EnDev I pilot project in Chua; and is still being used to design the intervention in other communities of EnDev II phase. Apart from that research, no other studies have been used by the EnDev promoters in Mozambique. No mechanism for collecting, monitoring or responding to consumer's information was being used by GIZ/AMES-M or AKSM at the time of the field work for this research. Thus, the score in regards to the use of consumer information for business planning is low.

EDA1.2 - Technology usability information is collected through field testing

The pilot project in Chua during EnDev I was useful to prove the feasibility of micro/pico hydropower projects in Manica province and in the country. After the Chua experience some modifications to the implementation strategy were introduced thanks to the lessons acquired during the pilot project. Nevertheless, at the time of the field work for this research there was no monitoring system being used in Chua in order to assess the performance of the technology and satisfaction of consumers. Hence, this indicator scores low.

[23] http://en.rwi-essen.de/

EDA1.3 - Level of regulatory knowledge held by project promoters is increased

An important part of GIZ/AMES-M strategy for the implementation of the EnDev initiatives is to work jointly with the local authorities. Consequently, important efforts are done by the EnDev promoters in Mozambique to work in a co-ordinated way with the MoE, FUNAE and also DIPREME at the provincial level. In this context, the EnDev implementation activities are planned in line with the governmental electrification objectives. The main goal of GIZ/AMES-M efforts in this sense is to build the local capacities for the development of a RETs sector in the country. Thus, the networking with regulatory officials is one of the crucial tasks ongoing for the EnDev intervention in the country. Consequently, the regulatory knowledge held by EnDev promoters has a high score.

EDA2 - Sales, Marketing, and Costumer Services activities

This issue was addressed during the interviews with GIZ/AMES-M, AKSM and the hydropower system owners/operators Lino Ndacada and Tomas W. Guarai.

EDA2.1 - Sales, marketing, and costumers service activities leverage trust and social networks

As it was mentioned previously, at the time of the field work in Manica province no mechanisms for collecting, monitoring or responding to consumer's information were being used by the EnDev project promoters; only AKSM was doing a follow-up of the Revolving Fund payments. Thus, there was not a formal sales, marketing or costumer services mechanism established for the EnDev systems operating. Nevertheless, the size of Chua village is pretty small, as well as the number of consumers per system; consequently for the owners/operators it is quite easy to get feedback/information from the beneficiaries. This was the only informal mechanism existing that might be used to leverage trust and social networks. Therefore the score for this indicator is low.

EDA2.2: Payment and finance mechanisms established are supportive of sustained system operation

Owners/operators of the Chua EnDev systems do not employ flexible consumer payment mechanisms. Actually the existing mechanism is quite rigid: all the consumers pay a fixed flat tariff monthly independent of the amount of electricity consumed, although the existing tariff is rather low (MZN 200). Additionally, as it is described in Annex I, the repayments of the households' connections cost go to a Revolving Fund for community development, which is much valued by the consumers and hence supportive of the sustained system operation.

On the other hand, GIZ/AMES-M signed in 2010 a MoU with Banco Terra for the financing of EnDev off-grid power generation initiatives. This is a recent but important step for the development of the micro/pico hydropower sector in Mozambique and it could be the beginning for the local banking system to develop more lending products for energy services.

Thus, the score in regard the payment and finance mechanisms supporting the sustainability of the EnDev systems is medium.

EDA3 - Financial management

This issue was addressed during the interviews with GIZ/AMES-M and AKSM.

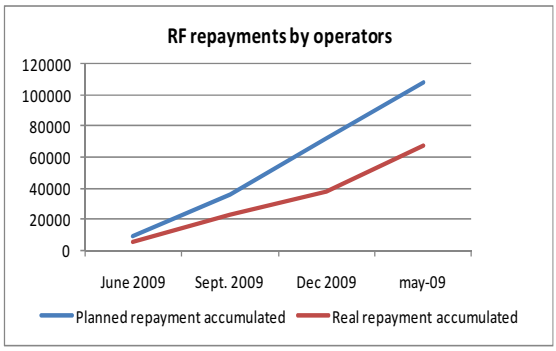
EDA3.1 - The EnDev projects are able to recover start-up and operational costs

For the Chua pilot projects only basic incomes/costs and repayment analyses were performed by the project promoters initially. As it is described in Annex I, the Chua projects were originally financed totally by the EnDev programme; nevertheless the owner/operator jointly with the consumers acquired a commitment to payback part of the investment for power generation and the household connection costs respectively. Such repayments are not exactly part of a loan since they go to the Revolving Fund that is used by the community, and hence would not be recovered by the EnDev programme.

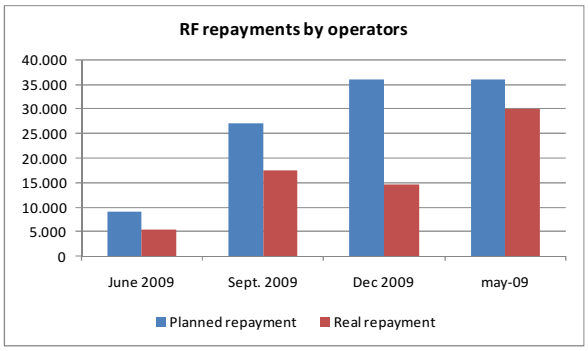
On the other hand, the EnDev project promoters calculated the subsidy granted to the projects owners/operators according to the potential number of consumers and electricity payments. Thus, theoretically the project owner/operators should be able to pay back the part of the investment that was not granted (the "loan") through the electricity payments from the consumers. The payback period was fixed in 24 months, period that at the moment of the field work in Manica was not yet finalized. Nevertheless, from a report elaborated by AKSM in April 2010[24] it was possible to gather that at that time the Revolving Fund (RF) repayments from owners/operators reached only 63% of the original planned payback; meanwhile the Revolving Fund repayments from households energy users was 51% of what should had been paid at that time according to the business design. At the same time, the income for owners/operators in Chua from payments for energy use was on average 35% of what they should have received according to the business design made by the EnDev promoters by that time.

The graphs in the next page show the situation described previously (all figures in MZN).

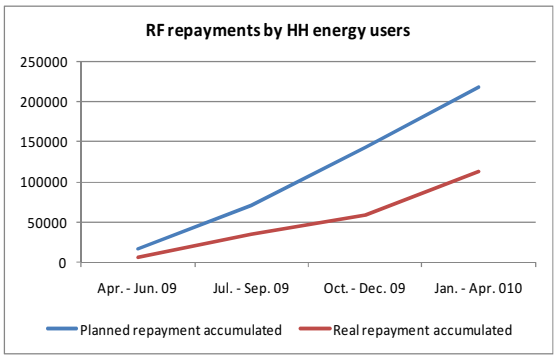
[24] Document "AKSM-Chua Micro Hydro Project Progress Report" (AKSM, 2010). This document was the most updated report at the time of this research.



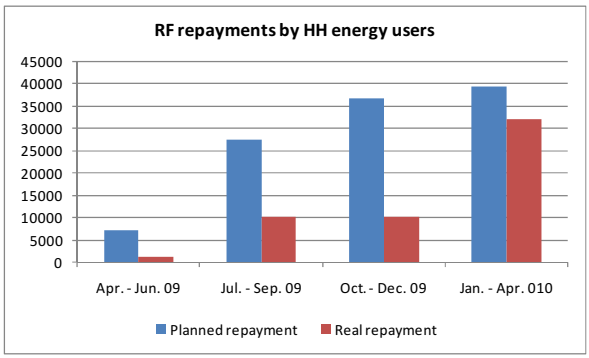
Graph 2: RF repayments by operators accumulated



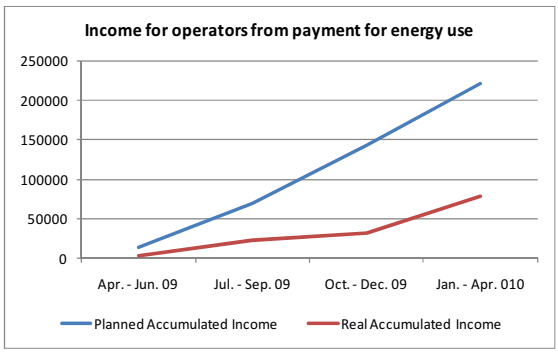
Graph 3: RF repayments by operators per period



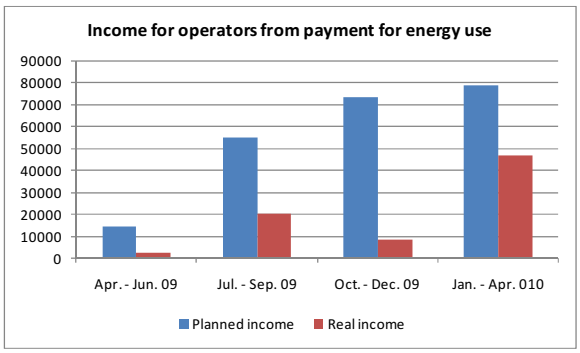
Graph 4: RF repayments by HH accumulated



Graph 5: RF repayments by HH per period



Graph 6: Operators' income from payments for energy use accumulated



Graph 7: Operators' income from payments for energy use per period

Thus, given the figures reported by AKSM in April 2010, it has not been proved yet that the operation of the implemented EnDev systems allows the owners/operators to pay back the "symbolic" loans to the Revolving Fund, and hence this indicator scores low.

Additionally, the MoU signed with Banco Terra will require a much more detailed financial analysis, a polished business plan and collaterals for the EnDev II projects that the bank would finance[25].

EDA3.2 - Scalability of the EnDev hydropower business is financially feasible

According to the information gathered from GIZ/AMES-M the EnDev hydropower systems being implemented do not have a business plan for expansion and scalability, nevertheless this does not mean that scalability is not possible. The recent involvement of Banco Terra in the micro/pico hydro sector is a good first step for future potential scalability plans. Additionally, the EnDev project promoters have analysed the possibility of engaging in carbon finance; nevertheless this option has been discarded given the low amount of carbon emission reductions originated by the hydropower systems and the high transaction costs of the carbon market.
Consequently, the scalability of the EnDev hydropower systems is not being considered today and hence it receives a low score.

EDA3.3 - The design and implementation of subsidies used is supportive of market development

In the case of the hydropower systems implemented in Manica the subsidy given by the EnDev programme touches the very poor directly. At the same time GIZ/AMES-S subsidies the training of local governmental and non-governmental entities through EnDev funds in order to build the local capacities and develop the micro/pico hydropower sector in the country.
In regard to the EnDev subsidy given directly for the implementation of the hydroelectric plants, a potential strategy to reduce/exit the subsidy could be through the productive use of energy; nevertheless an improved business model that allows the entrepreneurs to cover the operational costs will be a must. On the other hand, if the subsidy given for the implementation of each EnDev hydropower system is reduced without utilising a new business model that originates the monetary flows reduced from the subsidy, inevitably the cost of the electricity would have to increase affecting the willingness to pay of the consumers.

Therefore, it is crucial to improve the business model and strategy that GIZ/AMES-M is using to implement the EnDev hydropower systems. If local entities do not get motivated to develop the micro/pico hydroelectric sector, it will be not easy to make the sector take off.

Thus, for a real development of the market the GIZ/AMES-M hydropower business model (and then the subsidy) should be better designed in order to make the sector attractive for investors. This is certainly not an easy task, and GIZ/AMES-M has done a good job already proving the feasibility of the technology in the country. Consequently, this indicator scores medium considering the subsidies being used and its support for market development.

[25] *At the time of this research no projects were yet financed by Banco Terra.*

EDA4 - Operations of the hydropower systems

This issue was addressed during the interviews with GIZ/AMES-M, AKSM and the hydropower system owners/operators Lino Ndacada and Tomas W. Guarai.

EDA4.1 - Extent of monitoring and quality control

As it was mentioned earlier at the moment of the field work in Manica no formal monitoring mechanisms on energy consumption, satisfaction or energy use were existent. Only informal feedback had been gathered by the owners/operators. In this same context, the owners/operators had not received any kind of training in monitoring activities at the time of the research. Thus, no innovations were developed as a result of monitoring activities. Additionally, the generation systems did not have any type of certification.

In consequence, in terms of monitoring and quality control the EnDev hydropower systems operating in Manica have a low score.

Consequently, given the information gathered during the field work and presented here, the *Enterprise design and business planning* dimension receives a final overall score of 0.36, which according to the scoring systems proposed by the SAF-EnDev tool means a contribution to sustainability between low and medium.

IV. Details on the environmental sustainability of the EnDev hydropower systems

The *Environmental sustainability* of the EnDev initiatives is also a requisite for the sustained operation of the projects implemented. The main objective of this dimension was to determine if the hydropower systems were in line with the local environmental regulatory framework. The assessment here was based on the only indicator suggested by the SAF-EnDev tool. The findings are as follow:

ESA1 - Environmental sustainability of the EnDev hydropower systems operating

This issue was addressed during an interview with AKSM. The findings are as follow:

ESA1.1 - Environmental impacts of systems' operation

The Mozambican government has a regulatory framework under the Ministry for Environmental Coordination (MICOA[26]). At provincial level the MICOA is represented by DPCOA[27]. The regulatory framework is clear in terms of what is required and requested for each category of projects; depending on the size of the project a complete or simple environmental impact assessment (EIA) could be required. In the case of the EnDev hydropower systems implemented in Chua, no EIA was developed since the systems operate on maize mills that had been operating for a long time, thus the new activity did not need an EIA according to the local environmental regulation.

Thus, the EnDev micro/pico hydroelectric plants operating in Chua are in line with the local environmental regulation and therefore the score for this dimension is high.

Consequently, the operation of the EnDev hydropower systems in Chua enjoys a high contribution to the sustainability of the projects according to the indicators of the SAF-EnDev tool.

[26] *Ministério para a Coordenação Ambiental*

[27] *Direcção Provincial para Coordenação Ambiental*